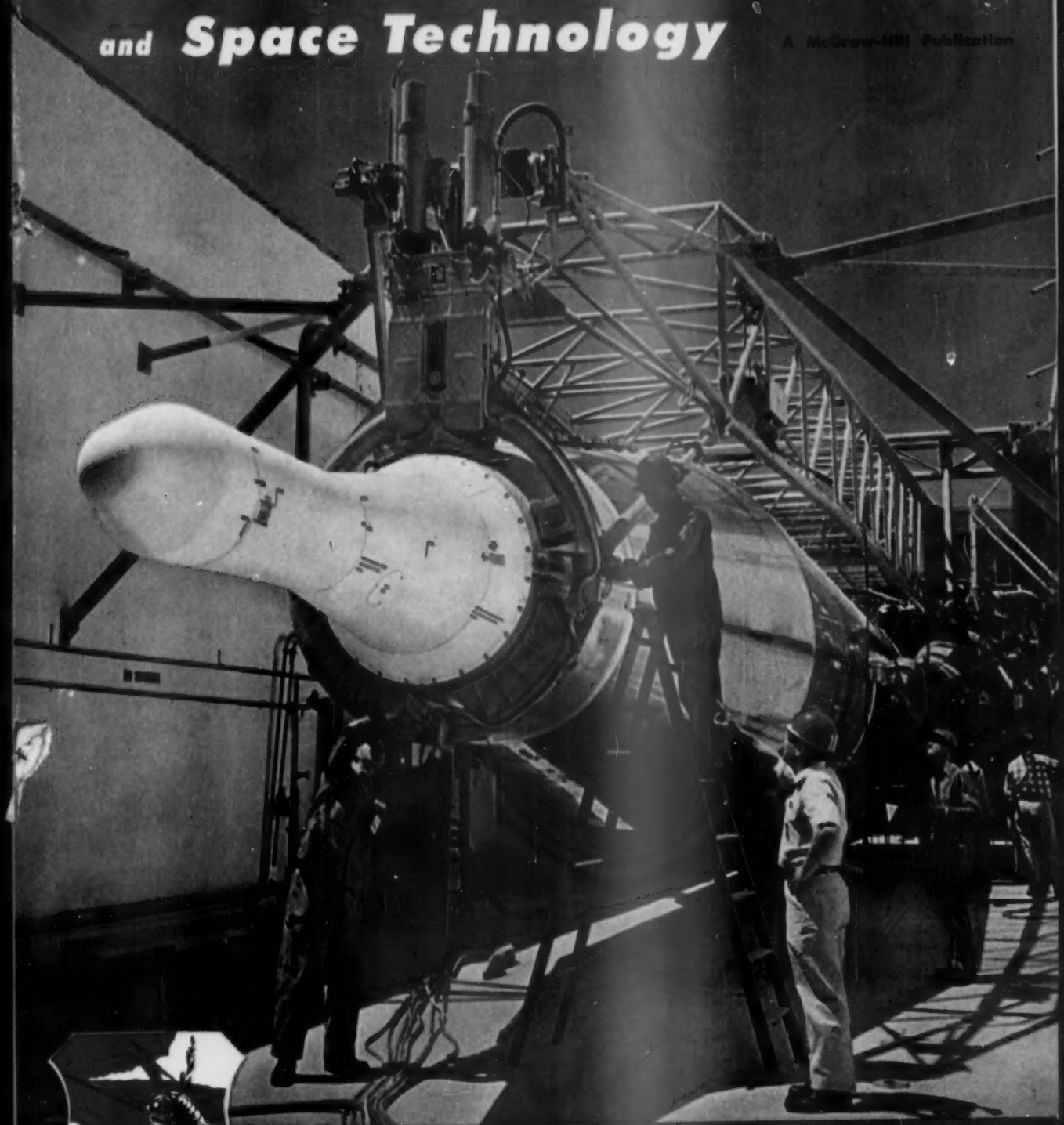
June 20, 1960

THIS ISSUE $1.00

Aviation Week

and Space Technology

A McGraw-Hill Publication



SAC IN TRANSITION

Special Report on STRATEGIC AIR COMMAND

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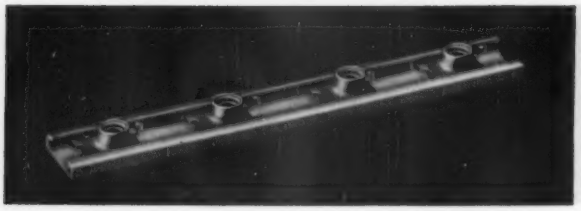

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first in lightweight locknuts

Using Kaylock® gang channel, instead of individual nuts, mounting time of printed circuit connectors was cut 66% in a time-motion study of electronic assembly at Hughes Aircraft Company, Fullerton, California. The part, a Kaylock G19199 miniature gang channel, uses tiny, all-metal, self-locking floating nuts and is available in any length up to 6 feet. Hughes engineers found that the gang channel had other important advantages. Workers could remain comfortably seated, no longer had to reach around the assembly to position the nuts. Need for a specially designed spin-type wrench was eliminated.

Kaylock miniature self-locking nuts and gang channel not only meet the highest requirements of airframe, jet engine, missile, and electronic manufacturers—but very often exceed top performance expectations. If you have a special locknut problem you would like to have solved, a Kaylock sales engineer is as near as your phone. Call him today.

Kaynar Mfg. Co., Inc., Kaylock Division, Box 2001, Terminal Annex, Los Angeles 54, Calif. Branch offices, warehouses & representatives in Wichita, Kansas; New York, N. Y.; Atlanta, Ga.; Renton, Wash. Canadian Distributor: Abercorn Aero, Ltd., Montreal, Quebec.

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these watchdogs scent danger with plastic nosesl

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All three radomes provide exceptional thermal, structural and electrical properties, and are built to extremely close tolerances by Goodyear.

The Snub-Nosed B-52 Radome, employing a honeycomb-sandwich construction, is one of the largest sandwich-type radomes ever designed for use on a high-speed aircraft.

The Needle-Nosed B-58 Radome, a solid laminate made of high-temperature-resistant resin, houses special equipment calling for a dimensionally precise radome.

The Low-Slung C-130 Heated Radome, a cored deicer, is one of the first successful *ducted* radomes built.

As a designer and fabricator, Goodyear Aircraft is unique in the industry—having the capability of combining metal and reinforced plastic know-how for engineering, producing and completely testing an entire radome assembly to meet the most stringent specifications.

These advanced methods and materials stem from Goodyear Aircraft's vast experience with all types and sizes of radomes – from airborne radomes to huge ground-based radomes (the largest: 140 foot diameter). Can this experience solve a problem for you? *Write* for full information to: Goodyear Aircraft Corporation, Dept. 916AR, Akron 15, Ohio.

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Search and Doppler radars for the B-58 Hustler's navigational and bombing systems are produced by Raytheon.

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RAYTHEON

EXCELLENCE IN ELECTRONICS

AVIATION CALENDAR

June 27-29—Fourth National Convention on Military Electronics, Institute of Radio Engineers, Sheraton-Park Hotel, Washington, D. C.

June 28-July 1—National Summer Meeting, Institute of the Aeronautical Sciences, Ambassador Hotel, Los Angeles, Calif.

July 3-4—Fourth Annual Fort Wayne National Championships (civilian, closed-course airplane races), Fort Wayne, Ind.

July 5-15—Special Summer Program in Inertial Guidance—Terrestrial and Interplanetary, Massachusetts Institute of Technology, Cambridge, Mass.

July 11-12—Conference on Response of Metals to High Velocity Deformation, Stanley Hotel, Estes Park, Colo. Sponsor: Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

July 18-19—Liquid Rockets and Propellants Conference, American Rocket Society, Ohio Union Building, Ohio State University, Columbus, Ohio.

July 28-29—Seventh Annual Symposium on Computers and Data Processing, Denver Research Institute, University of Denver, Stanley Hotel, Estes Park, Colo.

Aug. 1-3—Fourth Global Communications Symposium, Statler Hilton Hotel, Washington, D. C. Sponsors: Institute of Radio Engineers; U. S. Army Signal Corps.

Aug. 1-3—"Future of Manned Military Aircraft" (Classified Meeting), Institute of the Aeronautical Sciences, El Cortez Hotel, San Diego, Calif.

Aug. 2-11—27th Annual U. S. National Soaring Championships, Ector County Airport, Odessa, Tex.

Aug. 8-11—Western National Meeting, American Astronautical Society, Olympic Hotel, Seattle, Wash.

Aug. 8-12—1960 Pacific General Meeting, American Institute of Electrical Engineers, El Cortez Hotel, San Diego, Calif.

(Continued on page 6)

AVIATION WEEK and Space Technology

June 20, 1960
Vol. 72, No. 25

Published weekly with an additional issue in December by McGraw-Hill Publishing Company. James H. McGraw (1860-1948), Founder. See panel below for directions regarding subscription or change of address. Executive, Editorial, Circulation and Advertising Offices: McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Publication Offices, 99-129 North Broadway, Albany 1, N. Y. OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator. OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Joseph A. Gerardi, Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary.

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Single copies 75¢. This issue $1.00. Subscription rates—United States and possessions, $7 one year. Canada $8 one year. All other countries, $30 one year.

Second class postage paid at Albany 1, N. Y. Printed in U. S. A. Title registered in U. S. Patent Office.
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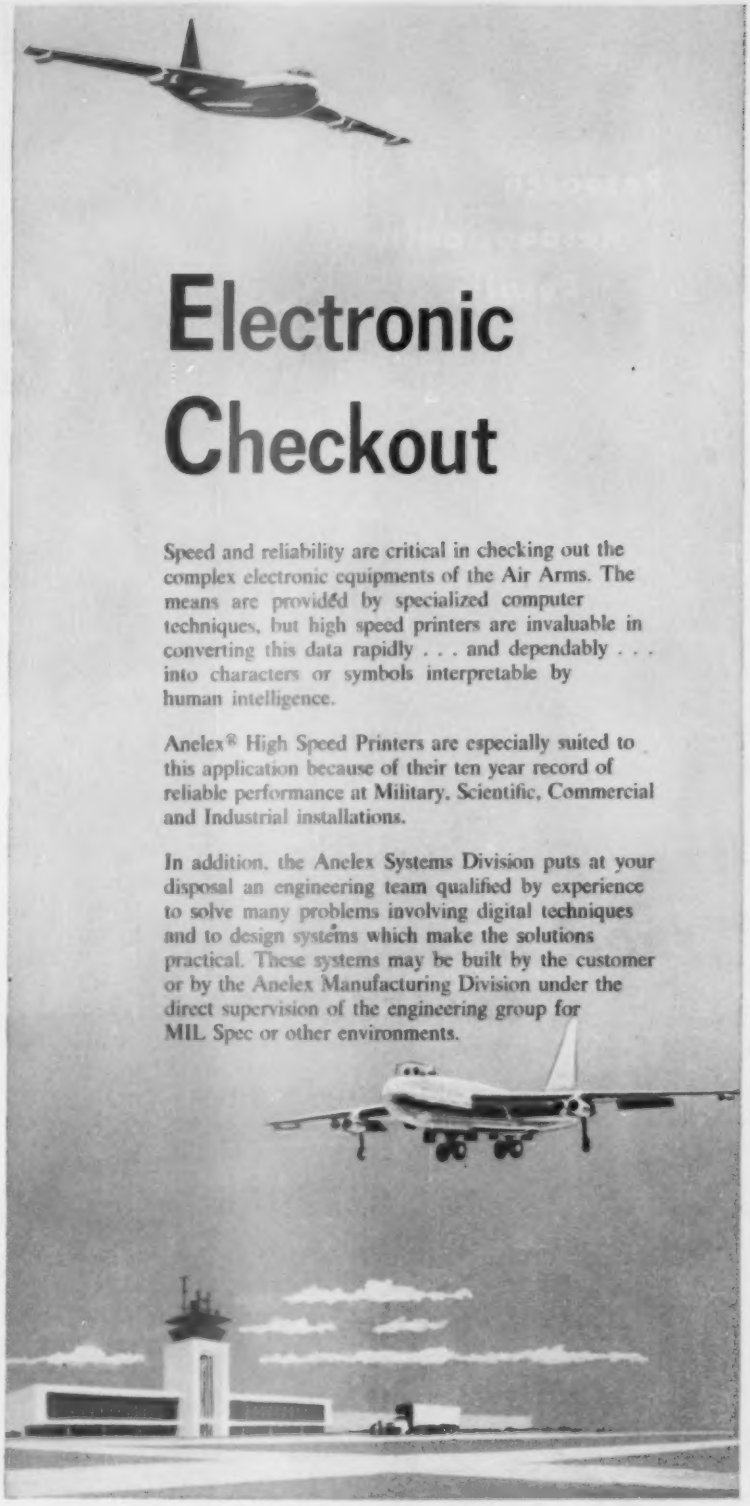
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Anelex® High Speed Printers are especially suited to this application because of their ten year record of reliable performance at Military, Scientific, Commercial and Industrial installations.
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AEROTHERM DIVISION • AIRCRAFT EQUIPMENT DIVISION • INDUSTRIAL DIVISION

AVIATION CALENDAR

(Continued from page 5)

Aug. 15-20—11th Annual Congress, International Astronautical Federation, Royal Institute of Technology, Stockholm.

Aug. 16-18—Fourth Annual Tri-Service Conference on Biological Effects of Microwave Radiation, New York University Post-Graduate Medical School, NYU Medical Center, N.Y.C. Sponsor: Air Research and Development Command.

Aug. 18-19—Second International Symposium on Submarine and Space Medicine, Laboratory of Aviation and Naval Medicine, Karolinska Institute, Stockholm.

Aug. 18-19—Electronic Packaging Symposium, University of Colorado, Boulder.

Aug. 23-25—1960 Cryogenic Engineering Conference, University of Colorado, Boulder, Colo.

Aug. 23-26—Western Electronic Show & Convention, Institute of Radio Engineers, Ambassador Hotel, Los Angeles, Calif.

Aug. 28-Sept. 5—1960 National Air Rally, Municipal Airport, Orange, Mass. Sponsor: National Aeronautic Assn.

Sept. 4-5—Civilian, Closed-Course Airplane Races, Lakefront Airport, Cleveland.

Sept. 5-11—1960 Farnborough Flying Display and Exhibition, Society of British Aircraft Constructors, Farnborough, Eng.

Sept. 7-9—Joint Automatic Control Conference, Massachusetts Institute of Technology, Cambridge, Mass. Sponsors: Instrument Society of America; American Society of Mechanical Engineers; American Institute of Electrical Engineers; Institute of Radio Engineers; American Institute of Chemical Engineers.

Sept. 8-9—1960 Engine and Operations Symposium, Airwork Corp., Millville.

Sept. 12-16—16th Annual General Meeting, IATA, Copenhagen, Denmark.

Sept. 12-16—Second International Congress, International Council of the Aeronautical Sciences, Zurich, Switzerland.

Sept. 14-16—Annual Meeting, National Assn. of State Aviation Officials, Wort Hotel, Jackson, Wyo.

Sept. 15-16—15th Annual Meeting, Armed Forces Chemical Assn., Sheraton-Park Hotel, Washington, D. C.

Sept. 19-22—National Symposium on Space Electronics and Telemetry, Institute of Radio Engineers, Shoreham Hotel, Washington, D. C.

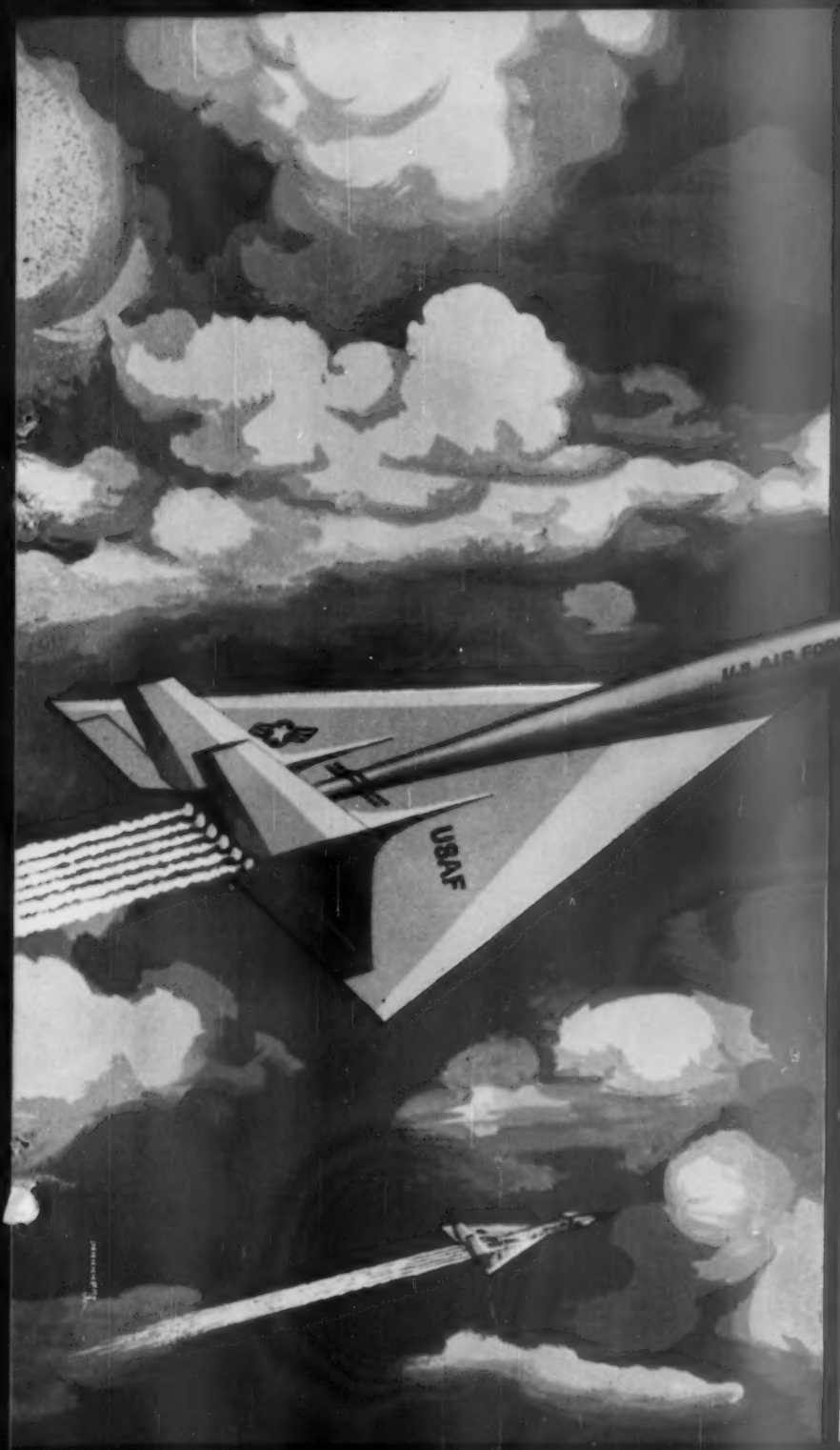
Sept. 21-25—National Convention and Aerospace Panorama, Air Force Assn., Civic Auditorium and Brooks Hall, San Francisco, Calif.

Sept. 27-30—Power Systems Conference, American Rocket Society, Miramar Hotel, Santa Monica, Calif. Cosponsors: USAF; U. S. Army; U. S. Navy; National Aeronautics and Space Administration; Atomic Energy Commission.

Oct. 3-5—Seventh Annual Meeting, Institute of Radio Engineers' Professional Group on Nuclear Science, Gatlinburg, Tenn. Cosponsor: Oak Ridge National Laboratory.

Oct. 3-5—National Midwestern Conference on Air Logistics, Institute of the Aeronautical Sciences, Tulsa, Okla.

Oct. 3-5—First International Air Traffic Control Conference and Fifth Annual Meeting of the Air Traffic Control Assn., Sheraton-Palace Hotel, San Francisco.



from Avco/Nashville ... structures for mach 3 aircraft

The prototype of the future for military and commercial aircraft, North American Aviation's B-70 *Valkyrie*, will include major structural components from Avco's Nashville Division.

Production of high strength-to-weight structures is a specialty of the Nashville Division. For that reason, Avco/Nashville was one of the companies selected to produce panels for a section of the B-70 fuselage. *Avcomb* panels of stainless steel honeycomb are exceptionally strong, yet light, and offer high resistance to heat. These tough panels are produced by a new process called *Avcoramic* tooling, designed to make better quality panels at lower cost.

Avco/Nashville's work also includes components for the new Convair 880 and 600 jet transports and for the Lockheed *Hercules* military transport. Nashville offers breadth and depth of experience in designing, engineering and producing all types of lightweight honeycomb structures, including aluminum, titanium, and fibre glass for aircraft, missiles, space vehicles, and radar reflectors.

New tooling processes for stainless steel honeycomb panels, together with Nashville's broad experience gained over many years, afford its customers a unique combination of quality and skill. Why not put this experience to work on your structural problems? *For more information write: General Marketing Manager—Structures, Nashville Division, Avco Corporation, Nashville 1, Tennessee.*

Avcoramic tooling for stainless steel honeycomb panels.

UNUSUAL CAREER OPPORTUNITIES FOR QUALIFIED SCIENTISTS AND ENGINEERS . . . WRITE AVCO/NASHVILLE TODAY.

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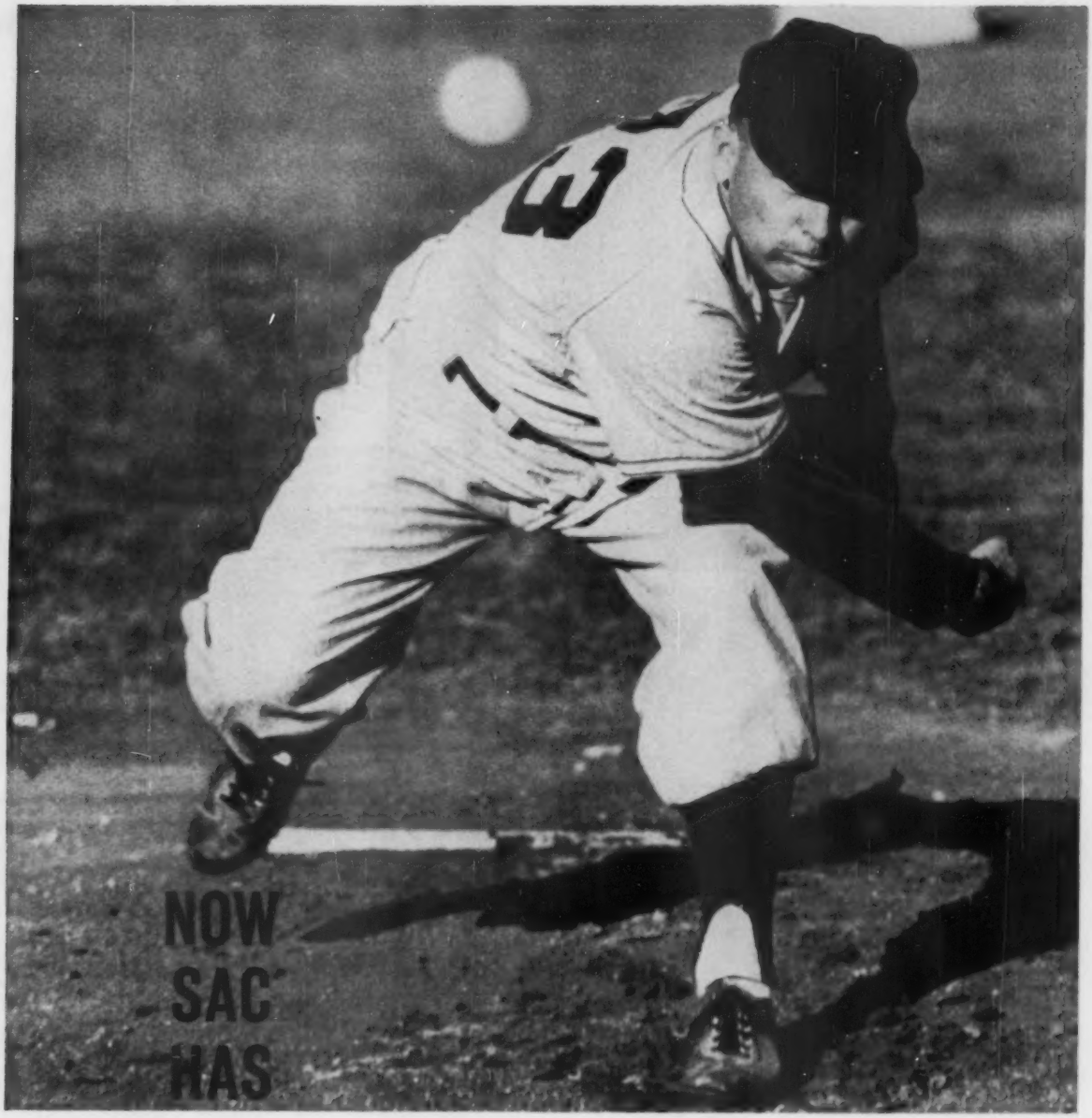

TWO STRIKES ON THE OPPOSITION

When SAC's B-52 crew steps up to the mound it can throw two deceptive curve balls before winding up to deliver the third strike. Two GAM-77 HOUND DOG air-to-surface missiles slung beneath the wings of the B-52 intercontinental bomber can quash enemy defense centers and clear a path to the main target.

Blazing into action at supersonic speeds, these GAM-77's can be used either on resistance points or on the main objective itself. Inertially guided, they can fox enemy radar by making passes at pseudo-targets before heading for the actual one. To further confuse the opposition, the jet-powered missiles can fly high or low on the way to the strike zone.

The GAM-77 HOUND DOG was designed and is in production for SAC by the Missile Division of North American Aviation.

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Downey, California

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a new line of Hyfen connectors for plug-in relays, including crystal can relays . . . crimp-type Hyfen terminations provide thousands of identical installations for stable electrical and mechanical performance under extreme conditions of vibration, shock, and acceleration. Sockets available to mate with relays of all leading manufacturers. For further information write Omaton Division,

Quickly installed individual crimp type terminations are easily removable and replaceable for flexibility of circuitry.

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HARRISON HEAT EXCHANGERS PROVIDE DUAL PROTECTION FOR CONVAIR F-106 . . . ALL-WEATHER JET INTERCEPTOR!

In a "red alert" . . . it's scramble and whoosh—altimeters soar above 50,000 ft.—thermometers dive below —50°! The devastating Dart—powered by a Pratt & Whitney J-75 turbojet engine in the 15,000 pound class—carries thousands of pounds of electronic eyes, muscles and brains plus deadly armament on its all-weather missions. Harrison heat exchangers provide dual protection for the Convair F-106 . . . controlling oil temperatures for the engine and the constant speed drive! Guarding vital operating temperatures on today's advanced aircraft is a Harrison specialty. It requires the engineering abilities, the research facilities and long experience in the heat-transfer field inherent in every Harrison product. If you have a cooling problem, look to the leader . . . rely on Harrison for the answer.

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HARRISON RADIATOR DIVISION, GENERAL MOTORS CORPORATION, LOCKPORT, NEW YORK

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zero plus

...and Carlson special stainless steels withstand the extremes of another launching

When this missile "lifts off," Carlson special stainless steel plates help launch it into space. These plates are the high strength, precipitation-hardening grades. And there are sound reasons why these grades are used.

First, with Armco 17-4PH, 17-7PH and PH15-7 Mo* it is easier to attain the high physical properties and resistance to elevated temperatures required in space flight engineering. Simplified low temperature heat treatment will develop a Rockwell hardness of C40 to C50. Tensile strengths, so vital in missile components, range from 180,000 to 220,000 psi in plates.

Second, only Carlson produces these Armco grades in the heavier plate thicknesses. For applications where high strength at high temperatures and ease of fabrication are important, get plates in these grades from Carlson. We will be glad to work with you on specific applications.

*17-4PH, 17-7PH and PH15-7 Mo are trade marks of Armco Steel Corporation

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Photo of Atlas missile courtesy
CONVAIR ASTRONAUTICS,
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A GOOD RUN FOR YOUR MONEY—

New "SCOTCH" BRAND Heavy Duty Tapes offer exceptional life, low rub-off, good resolution

HAVE PROBLEMS OF TAPE-LIFE, rub-off and resolution? To cure your headaches in applications that subject magnetic tape to high speeds, pressures, temperatures and low humidity, "SCOTCH" BRAND now prescribes two new tapes—Heavy Duty Tapes 198 and 199. They offer plus-performance in a wide variety of temperature and humidity conditions.

Take the matter of wear, for instance. Field tests show that "SCOTCH" BRAND Heavy Duty Tapes wear five times longer than standard tapes—yet they maintain good resolution and freedom from drop-outs over this long haul. Two factors are decisive in this performance—resistance to rub-off and resistance to high temperatures.

Ordinary tapes age fast if the temperature climbs or the relative humidity drops sharply. The binder softens, allowing the oxides to rub off on those costly and sensitive heads. Further, as an electrostatic charge builds with each pass, stray contaminants are attracted to the tape—and the tape starts to cling to the equipment. In each case—your drop-out count mounts.

Not so with "SCOTCH" BRAND Heavy Duty Tapes. They boast an extra tough binder system similar to that used in "SCOTCH" BRAND Video Tape, the first and most thoroughly time-tested video tape available. The heavy duty binder system anchors the oxides firmly to the polyester base in a way that resists very high temperatures—minimizing rub-off. Moreover, Heavy Duty Tapes have a conductivity nearly 1000 times greater than conventional tapes, allowing static charge to drain off. Result? Clean, smooth runs with good resolution—a good run for your money.

Performance of this kind is easy to promise—much harder to deliver. And only experienced "SCOTCH" BRAND technology has such a record of delivering the right tape for every application in data acquisition, reduction or control programming.

Check all the tapes in the "SCOTCH" BRAND line. High Resolution Tapes 158 and 159 pack more bits per inch, offer extra play time. High Output Tape 128 gives top output in low frequencies, even in temperature extremes. Sandwich Tapes 188 and 189 drastically cut head-wear, eliminate oxide rub-off, and wear 10 times longer than ordinary tapes. Standard Tapes 108 and 109 remain the standard of instrumentation.

Your 3M Representative is close at hand in all major cities—a convenient source of supply and information. For details consult him or write Magnetic Products Div., 3M Co., St. Paul 6, Minn.

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SCOTCH BRAND MAGNETIC TAPE

FOR INSTRUMENTATION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

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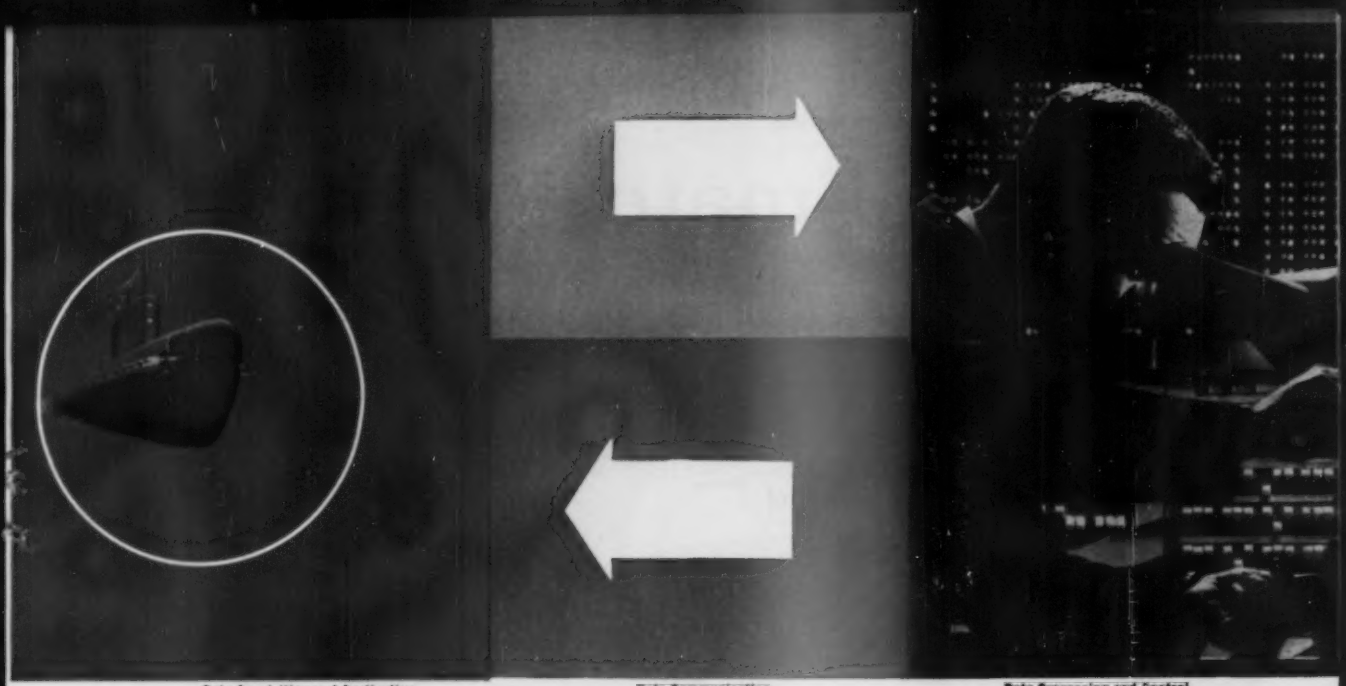

Data Acquisition and Application | Data Communication | Data Processing and Control

The 3 elements of an automated military system: all systems integration capabilities of IBM

This three-way capability makes IBM's Federal Systems Division the logical choice to handle study or development contracts—or to assume total systems integration responsibility.

IBM recognizes the importance of the fiduciary relationship that must exist between the prime contractor and the government. Through a continuing policy of customer service, IBM has gained a reputation for looking at problems through the customer's eyes. The Federal Systems Division is organized to bring this capability to a wide range of government requirements.

In data acquisition and application subsystems—IBM has the manpower and know-how to develop and furnish sensors, displays, and other devices for man-to-application, and machine-to-application communications.

In data communication subsystems—With knowledge and experience in IBM Tele-processing*, Federal Systems has the capabilities needed to design and develop complete networks to meet systems requirements. This includes, for example, subsystems with message-switching functions and terminal instrumentation. Message-processing equipment, inquiry stations, and code, modulation-demodulation equipment are being further developed in the Division's laboratories.

In data processing and control subsystems—Engineers and scientists at the Federal Systems Division can draw on a vast IBM background in data processing to develop new and advanced systems and programming concepts. They can take existing equipment, or utilize widespread manufacturing facilities to meet both the development and production requirements of totally new instrumentation.

The three elements of a military system are all logical capabilities of IBM's Federal Systems Division—for development *and* systems integration.

Federal Systems Division, International Business Machines Corporation, 326 East Montgomery Avenue, Rockville, Maryland **IBM®**

Data Acquisition and Application | Data Communication | Data Processing and Control

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Circle Number 13 on Reader-Service Card

SILICONE NEWS from Dow Corning

In Any Climate, Flexibility

SILASTIC Seals Fairchild F-27 Doors at -50 F

Fairchild's new F-27 propjet brings back the days of the versatile, multi-purpose transport. And one of the reasons this plane can fly anywhere, sit overnight on icy Alaskan runways, and carry a "flexible" payload is Silastic®, the Dow Corning silicone rubber.

This sounds like a lot to ascribe to a door seal, but it does play a really important part. The F-27B's for Northern Consolidated Airlines must be ready to roll in spite of —50 F ground temperatures. Their passenger doors and big cargo doors need Silastic seals because Silastic stays rubbery down to —130 or up to 500 F. With an organic rubber seal, the doors wouldn't open and close at —50. Silastic also resists equatorial weather, and springs back to shape after being compressed under load. So when the door opens to load either passengers or cargo, it will come shut again on a reliable seal that keeps its original properties and holds cabin pressure.

This is typical of the many applications of Silastic in transports, helicopters, military aircraft and other types of planes . . . missiles, too. Your rubber fabricator can engineer a part made of Silastic to your specifications. Or write Dept. 1006.

If you consider all the properties of a silicone rubber, you'll specify Silastic.

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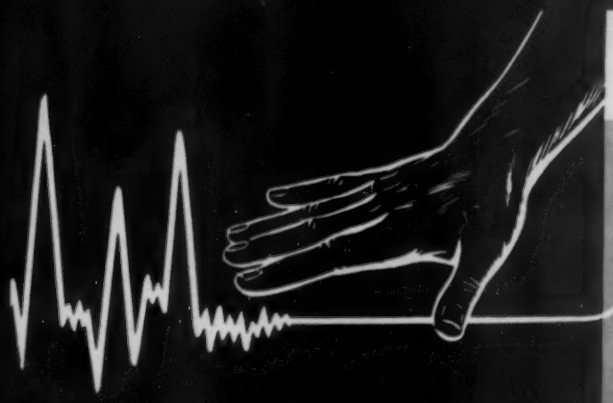

ROBINSON

Vibration and Shock Control

PROTECTS PERFORMANCE

and assures RELIABILITY in Vital Weapons Systems

for

missiles

Robinson all-metal MET-L-FLEX® mounting systems are ***now*** protecting certain components and items of sensitive equipment installed in the Atlas, Titan, Polaris, Bomarc, Lacrosse and other important missiles. Advanced space projects will depend heavily upon the specialized engineering resources that are available at Robinson to achieve reliability through environmental control.

aircraft

Today every major commercial and military aircraft including intercontinental and medium range jet bombers, supersonic fighter-bombers and interceptors, trainers, tankers, cargo and reconnaissance planes, are equipped with all-metal mounting systems designed by Robinson to protect many vital components.

surface ships and submarines

Robinson pioneered in the development and production of new ***low frequency*** shipboard mounting systems for the Navy's new single sideband communications equipment. These all-metal mountings have been specified by the Navy for installation in nuclear submarines and surface craft.

vehicles

Rugged, all-metal mounts have been designed, tested, and accepted to protect the latest communications and electronic equipment installed in tanks, trucks, jeeps, command cars, and other military vehicles. The operational life of the electronic components will be extended and reliability increased.

VIBRATION CONTROL IS RELIABILITY CONTROL

ROBINSON *Technical Products Inc*

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DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS

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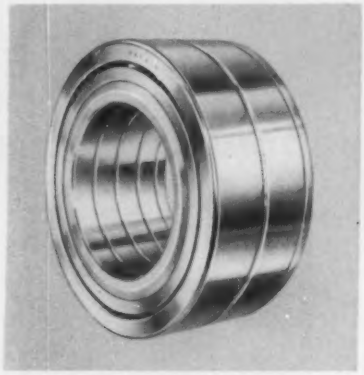
"THUMBNAIL CATALOG" OF FAFNIR BALL BEARINGS FOR DESIGNERS OF JET ENGINES, CONTROLS, AND ACCESSORIES

Jet Engine Bearings

Custom-engineered to specific load, speed, temperature, other requirements. Typical main rotor bearing shown is fabricated of specially proc-



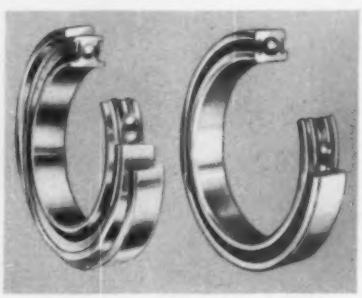
Jet Engine Main Rotor Bearing

essed alloy steels, the cleanest available. It is an angular contact type bearing with intricate split inner ring. All components are precisely fitted. Balls and raceways are precision-finished to millionths of an inch.

Fafnir has produced jet engine bearings in quantity for several years.

Control Bearings

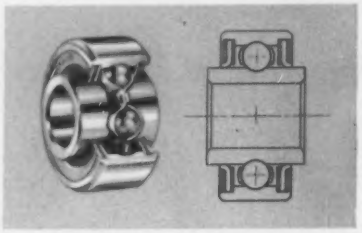
• **Special Precision Series** — The first control bearings made to special precision tolerances to meet the more demanding requirements of high speed aircraft. Boundary dimensions and eccentricities are held to closer precision tolerances than standard series bearings. Bore and outside diameter tolerances are decreased, and radial play is held to a reduced value.



M-Series Torque Tube Type Bearings

Fafnir Special Precision Control Bearings provide increased sensitivity in powered control systems, and help minimize backlash in the pilot-stick to power boost section of the system. Bearings in this series are identified by the prefix "M" in the bearing number.

• **High Temperature Bearings** — The first to be developed specifically for control systems in high Mach. number aircraft. Designated the AW-AK Series, these bearings are counterparts



AW-AK 440C Stainless Steel Bearing

of Fafnir's standard series KP-A type, but are fabricated of heat stabilized 440C stainless steel to withstand 500° to 600° F temperatures.

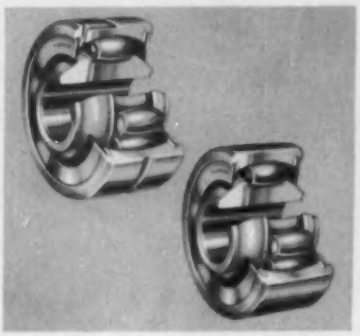
Available with heat-resistant, "low drag" special seals. Bearing widths to close tolerances permit ready mounting in standard brackets. Especially suitable for application in the critical area forward of the power boost system.

• **Balanced Design Rod Ends** — Rod ends in this series were the first to be engineered for balanced design. The shank strength, bolt strength, and bearing capacity are kept in balance for more compact, yet rugged construction.

Shank threads are precision-rolled with rounded roots to assure maximum strength and fatigue life. Available with roller bearings for power-operated systems, or ball bearings for manually operated systems.

Ball and Roller Bearing Rod Ends

• **High Capacity Types** — DSRP and GDSRP bearings offer most capacity for weight and size. DSRP bearings have removable seals for lubrication and inspection. GDSRP bearings are dimensionally interchangeable but have built-in provision for relubrication. Features include a full complement of precision rollers, large roller-to-race contact, and seals designed to



DSRP, GDSRP High Capacity Bearings

resist damage in case of severe bearing misalignments.

• **Helicopter Bearings** — Typical of Fafnir's helicopter bearings are the Y-PWI Series designed especially for swash plate applications. The series consists of matched pairs of thin-section, angular contact type bearings equipped with flexible Plya-Seals. Seals are removable for bearing inspection or relubrication.

Accessory Bearings

Extra-Small Bearing

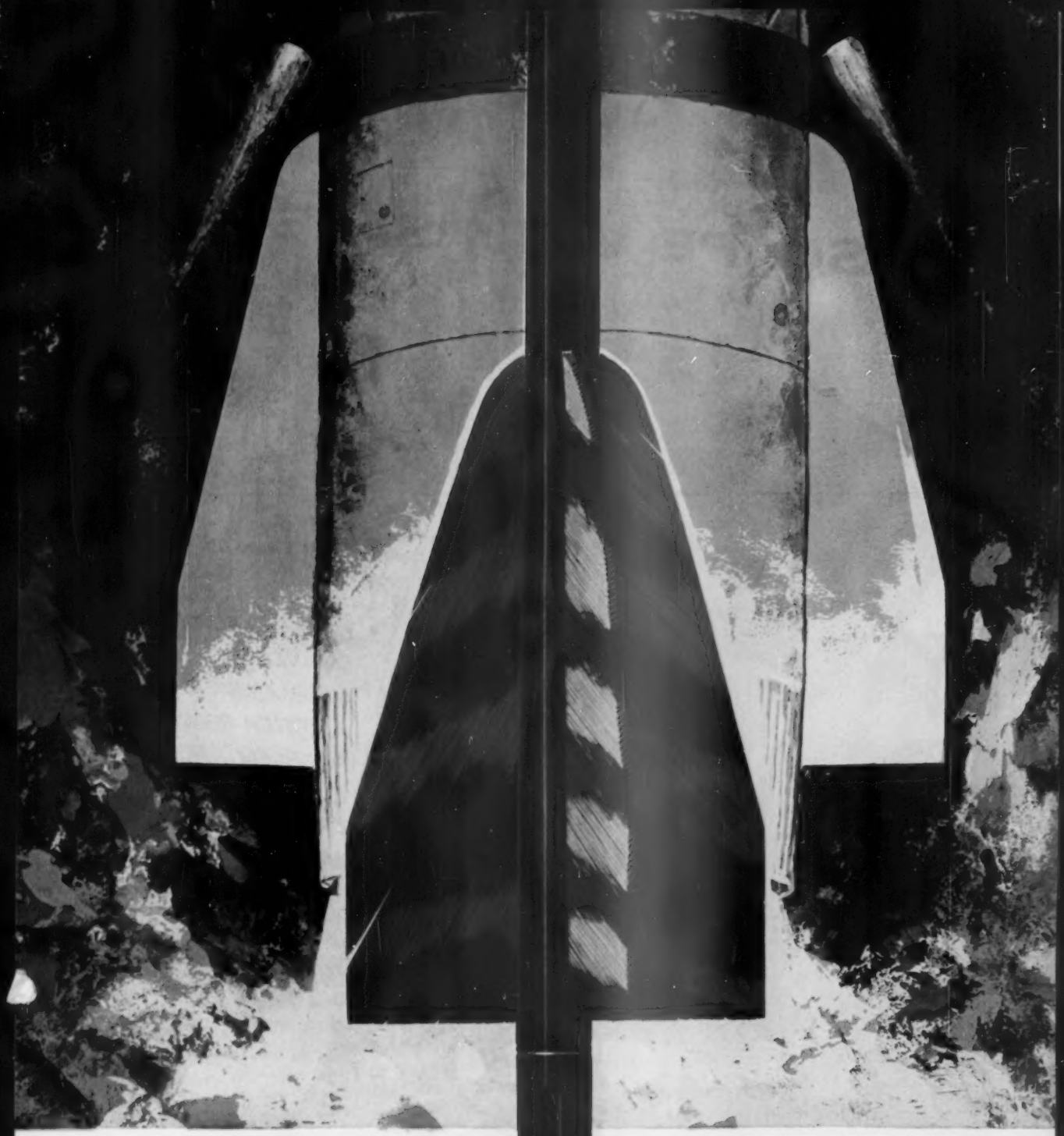
More than 10,000 bearing types and sizes in the Fafnir line, including a broad selection of extra-small bearings in inch and metric dimensions, offer answers to a wide variety of accessory equipment requirements. Special steels and exotic materials are available for high temperature applications or extremely corrosive conditions. A variety of integral seals, and shields are available for virtually any service conditions. Tolerance classes cover all precision requirements.

The bearings described here represent only a small selection from Fafnir's extensive line for use in aircraft. Back of them is some 30 years' experience with the industry's requirements — experience that has helped establish Fafnir as a leading supplier of bearings for aircraft engines, controls, and accessories.

For further information about any of the bearings described here or others in the Fafnir line — or for engineering help — contact your Fafnir branch office. Or write direct to The Fafnir Bearing Company, New Britain, Conn.

FAFNIR
BALL BEARINGS

Circle Number 16 on Reader-Service Card



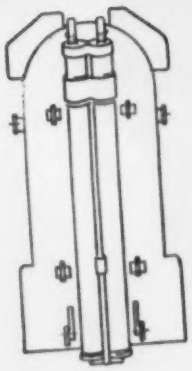
Swedlow **MATERIONICS**

Stone age profile on a space age missile. But in performance: progress in the science of fabricating advanced materials. In Swedlow language: MATERIONICS. In Swedlow practice: the insight to solve challenging problems of design and producibility of transparent plastic glazing, high temperature reinforced plastics—laminates, complex shapes, difficult parts—suppliers of flame resistant flexible coatings. Write for Facilities Report "Z," to Dept. 10.

Circle Number 17 on Reader-Service Card SWEDLOW Inc. / LOS ANGELES 22, CALIFORNIA / YOUNGSTOWN 9, OHIO

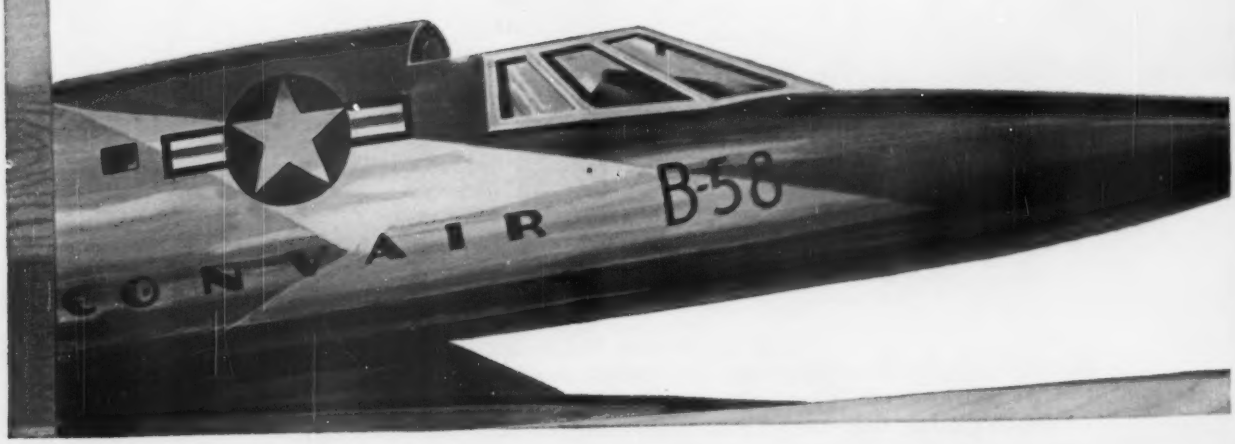
ESCAPE WITH SAFETY AT

1.

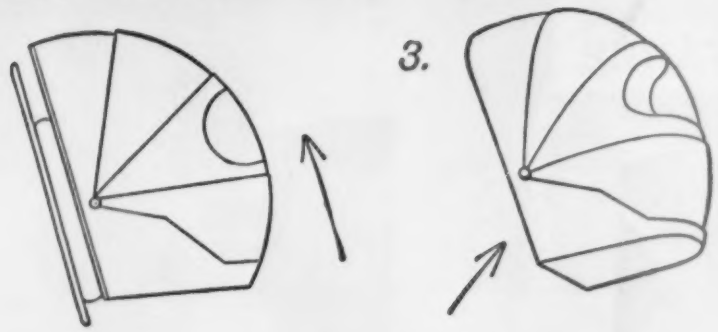


THIOKOL'S ADVANCED ENGINEERING SKILLS HELP ANSWER ANOTHER SPACE AGE PROBLEM... NOW PILOT EJECTION FROM AIR-CRAFT MOVING AT MACH 2 OR BETTER.

ESCAPE CAPSULE DEVELOPED BY STANLEY AVIATION CORP. FOR THE CONVAIR B-58 IS POWERED BY UNIQUE LOW THRUST ROCKETS SPECIALLY DESIGNED BY THIOKOL



SUPERSONIC SPEEDS !



$$m\ddot{y} = F_y - \alpha W\cos\chi - \mu(|N_1| + |N_2| + |N_3|)$$
$$+ F_E + F_R\cos\phi \quad \text{---} \quad y \in (l_n - d_E)$$
$$I_B\ddot{\theta} = M + F_y d_{11}\cos(\theta+\Theta) + F_x d_{11}$$
$$\sin(\beta+\Theta) - F_R d_E \sin(\phi-\Theta)$$
$$-\alpha W d_{12}\cos(\chi+\lambda+\Theta) - m\ddot{y} d_{12}$$
$$\cos(\lambda+\Theta)$$
$$m[y + d_{12}\Theta\cos(\lambda+\Theta) - d_{12}\dot{\Theta}^2\sin(\lambda+\Theta) =$$

$$\underline{V}c = iu + jv + kw$$
$$\underline{\Omega}c = ip + jq + kr$$
$$F = m\frac{(\delta \underline{V}c)}{(\delta t)}$$
$$Fx = m(\dot{u} + wq - vr)$$
$$Fy = m(\dot{v} + ur - wp)$$
$$Fz = m(\dot{w} + vp - uq)$$

Fig. 1. Pilot sits and works in escape unit. THIOKOL two-barrelled catapult powered by dual rocket engines attached to back of capsule.

Fig. 2. At start of escape cycle, THIOKOL slow burning propellant activates catapult. Acceleration control built into propellant saves occupant from injury. Capsule is propelled from airframe.

Fig. 3. Rocket motors, ignited automatically at end of catapult stroke, propel capsule to safe area above airframe—clear of vertical tail. In high or zero altitude escape, capsule attains sufficient height for parachute to open and arrest fall.

From design, development and production of propulsion systems for major missiles to specialized applications of rocket power, THIOKOL engineering skills are meeting the problems of the space age. THIOKOL means reliability—in every way.

Scientists, Engineers: perhaps there's a place for you on the THIOKOL team. Our new projects present stimulating challenge, opportunity for growth and commensurate rewards.

Thiokol®
CHEMICAL CORPORATION
Hunter-Bristol Division
Bristol, Pennsylvania

A 5000° flame takes ten minutes to penetrate a one-quarter inch piece of CDF's new Dilecto RD-105 laminate. The same thickness of cold-rolled steel is pierced in less than forty seconds.

Molded from graphite fabric impregnated with a heat (ablation)-resistant phenolic resin, new CDF grades RD-105 and RD-115 are being evaluated in solid propellant rocket motors.

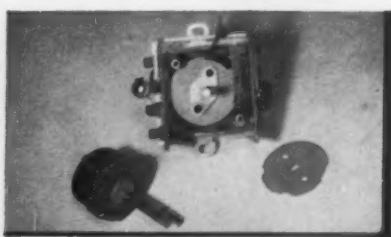
Dilecto laminates are only one family of products from industry's largest selection of non-metallic structural materials and electrical insulations. Vulcanized fibre, silicone rubber and mica, and thermosetting moldings are also supplied by CDF.

CDF can provide both quality and true economy in selecting plastic materials best suited to your needs. Refer to SWEETS PD file or write to us for General Folder 60.

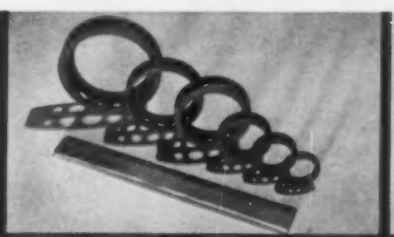
CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 19, DEL.

In Canada, 46 Hollinger Road, Toronto 16, Ont.



Moisture-resistant and low cost Dilecto cams for automatic washer and dryer controls.



Dimensionally stable, light weight, oil-resistant Dilecto ball bearing retainer rings.

Easily fabricated paper-base, punching grade Dilecto precision switch insulators.

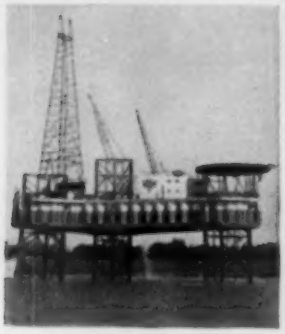
Circle Number 20 on Reader-Service Card

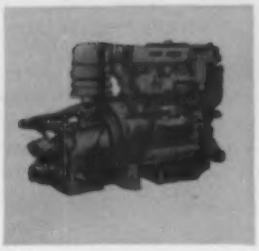
WHO TOOK THE DIESEL ENGINE OFF ITS HEAVY FOUNDATION?

Pre-1931 diesel engines were big and heavy. Although they were efficient, economical and uncomplicated, they only could be used where there was room for their bulk and for the massive foundations they required. Diesels, at that time, couldn't be used for mobile applications like those Caterpillar required. So Caterpillar designed and built its own diesels.

Compact, lighter and more versatile—the first Cat Diesel Engine revolutionized mobile power.

Today, with over thirty years of diesel experience, Caterpillar has built hundreds of thousands of these compression-ignition





engine power
BY CATERPILLAR

engines. Modern Cat Diesels are light, compact and efficient. They are probably the most advanced diesel engines made. They are available for practically every diesel or natural gas application.

Modern, lightweight, compact Cat Diesel Engines are available in horsepowers to 730 or Electric Set ratings to 375 KW. For use in construction, mining, railroad, petroleum, agricultural, marine, pleasure craft, logging, and public service applications.

CATERPILLAR

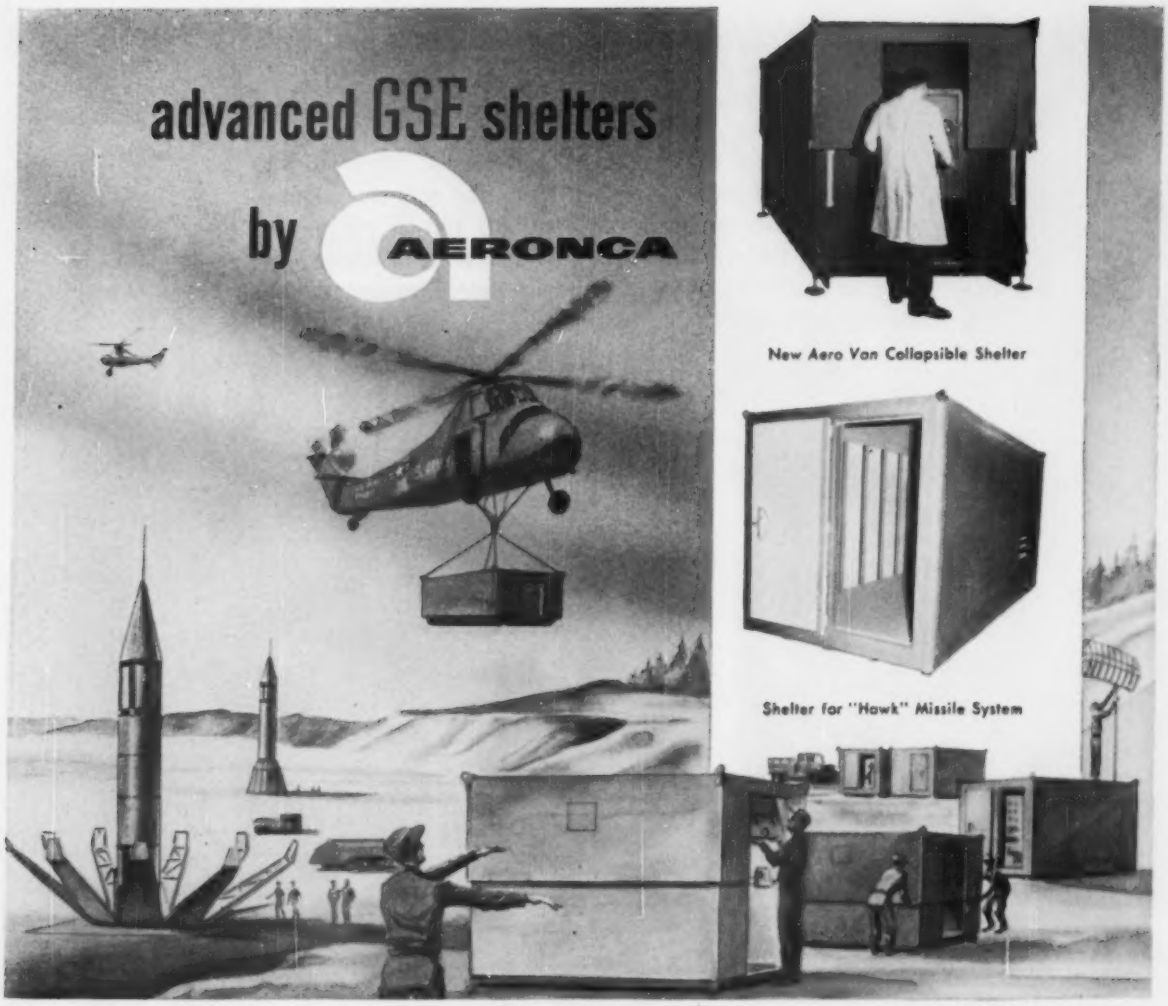
Engine Division, Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

advanced GSE shelters by AERONCA

New *Aero Van* Collapsible Shelter

Shelter for "Hawk" Missile System



8895-AC

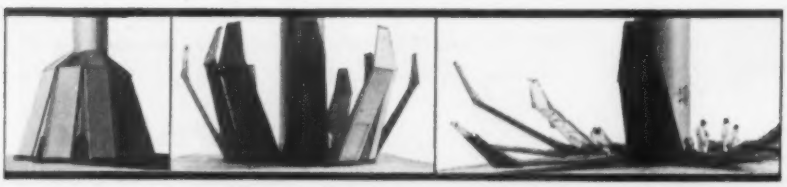
AERONCA DESIGNS, TOOLS AND PRODUCES NEW CONCEPTS IN LIGHTWEIGHT HIGH-STRENGTH AIR TRANSPORTABLE SHELTERS

Created by specialists in aircraft and missile weapon systems and sub-systems, *Aero Van* airborne shelters feature extreme versatility for world-wide applications. These new shelters achieve superior strength-weight ratios as well as interior flexibility through new design and construction concepts. In addition, they are designed for ease of modification and low-cost mass production.

Rugged all-purpose *Aero Van* shelters have been subjected to severe structural, environmental and suitability evaluation tests conducted by Armed Forces testing agencies.

Whatever your GSE shelter requirements, Aeronca can provide a "packaged" capability . . . from original concept to finished product . . . to meet your specifications. *FOR DETAILS, WRITE FOR BULLETIN AS-103.*

ANOTHER CURRENT GSE PROJECT AT AERONCA . . .



These photos show performance tests on a production model of new tactical shelter for "Jupiter" IRBM.

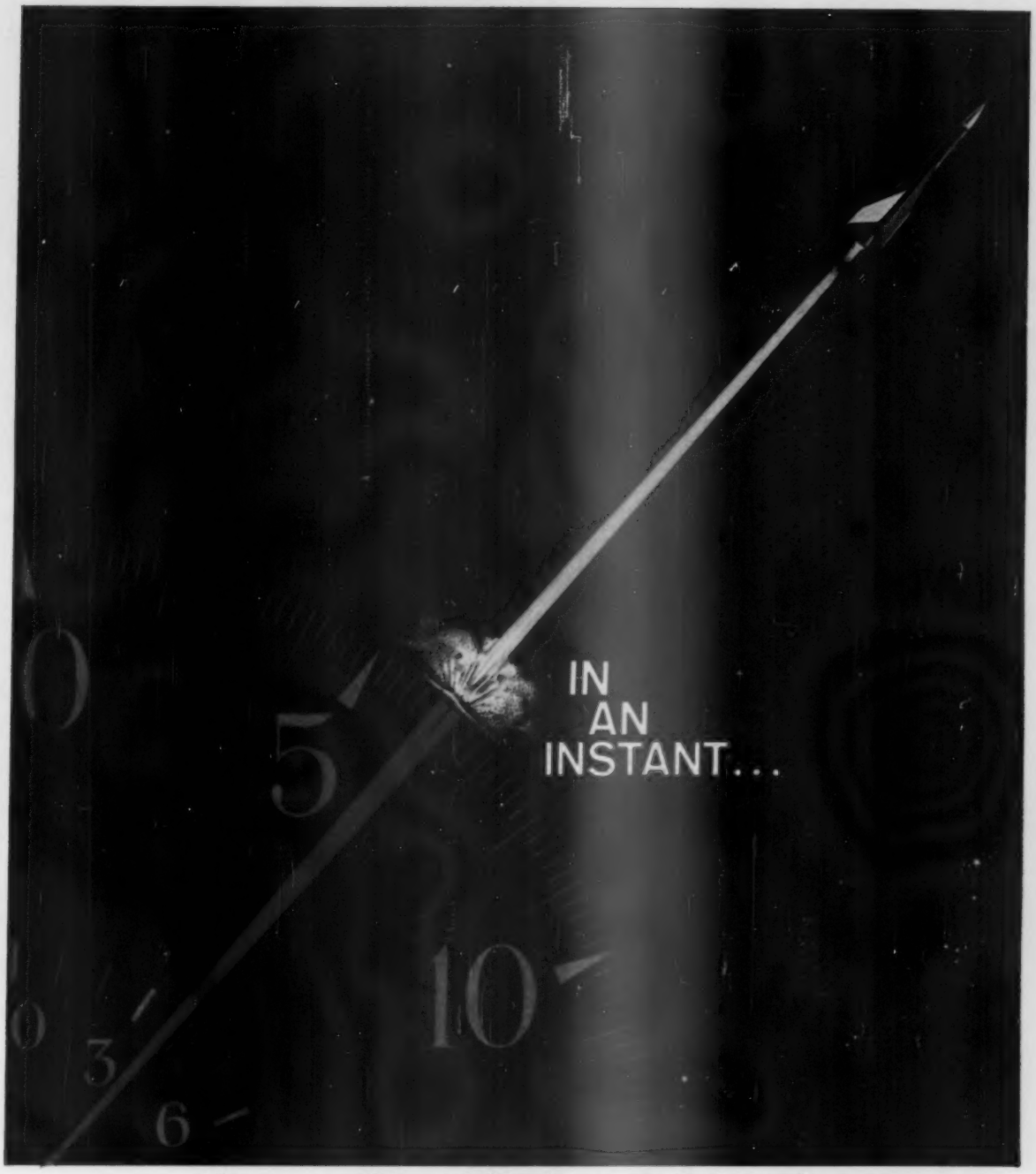
AERONCA

manufacturing corporation

1714 Germantown Road • Middletown, Ohio

Openings for creative R&D Engineers with Missile-Space experience. Write to O. E. Chandler, Mgr. Professional Employment.

Circle Number 22 on Reader-Service Card



because this oxidizer's stored aboard

Nitrogen Tetroxide provides immediate, hypergolic ignition with amine fuels. Even after 9 years of storage, nitrogen tetroxide is ready for instant use. Combustion efficiencies closely approach the theoretical 99%.

N_2O_4—**Requires no refrigeration**—can be stored indefinitely in missiles at launching sites.—**Can be used with most fuels**—including those containing carbon.—**Eliminates rough starts**—fast reaction prevents accumulation of propellants in thrust chambers.—**Allows throttleable control** of motors.

We'll gladly supply technical literature, including: a 59-page Product Bulletin, and a brochure entitled "Large Scale Handling of Nitrogen Tetroxide."

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyers Guide, pages 37-44.

BASIC TO AMERICA'S PROGRESS

Allied Chemical

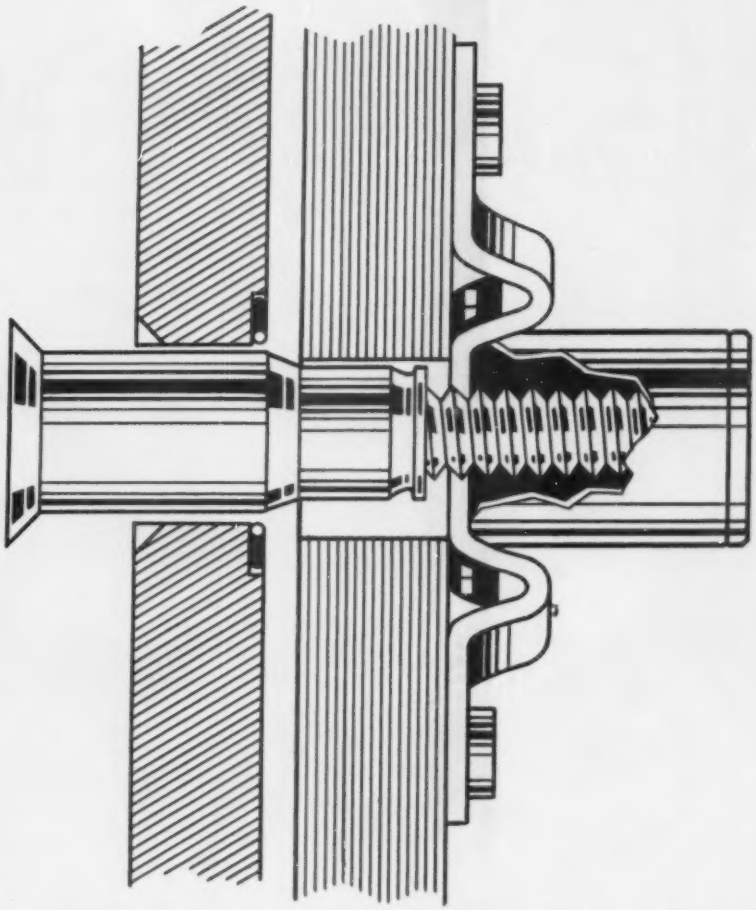
NITROGEN DIVISION
Dept. NT14-59-1, 40 Rector Street, New York 6, N.Y.

2819

Circle Number 23 on Reader-Service Card

SPS solves your panel alignment problems!

New fastener **overcomes hole mismatch** up to .040 inch



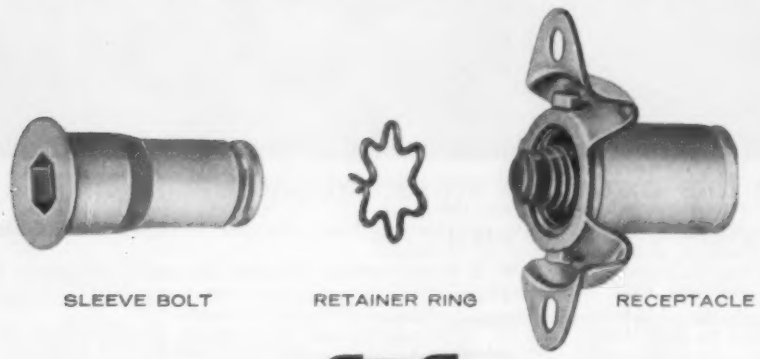
Self-aligning, self-jacking action results from tapered shoulder of sleeve bolt and the fact that at least one complete thread is engaged before shoulder contacts substructure. Double-lead thread seats fastener in just four wrenching turns, speeds assembly and removal.

HERE IS a high-strength self-locking panel fastener that will jack itself through holes as much as .040 inch out of line—without binding. It eliminates need for preliminary alignment with drift pins, makes installation and removal of panels a simple operation. Furthermore, it is fast—four turns or less to tighten.

Simple and foolproof in construction, this Milson*-type structural panel fastener consists of only three parts, none of which—after initial installation—will drop out or be misplaced when panels are removed. Also no special tools are re ,uired. An ordinary hex key does the job. And equally important, the fastener can be reused hundreds of times without loss of locking reliability or holding power.

You can specify Nutt-Shel Milson-type fasteners in ¼, 5/16 or ⅜ inch sleeve bolt shank diameters, with flat or 100° flush heads. Receptacles are available in both standard 2-lug and corner types, floating or self-sealing design. For complete data, write STANDARD PRESSED STEEL CO.—manufacturer of precision threaded fasteners and allied products in many metals, including titanium. Request new Bulletin 2616. AIRCRAFT/MISSILE Division, SPS, JENKINTOWN 3, PENNSYLVANIA • SANTA ANA, CALIFORNIA.

*Pat. pend.



Performance and Materials Data, SPS 1900 Series Fasteners

ALLOWABLE LOADS

⅜ inch diameter:
11,600 lb. min. double shear strength
6000 lb. min. tensile strength

5/16 inch diameter:
9500 lb. min. double shear strength
3500 lb. min. tensile strength

¼ inch diameter:
4500 lb. min. double shear strength
2000 lb. min. tensile strength

MATERIALS

Sleeve bolt and receptacle:
Alloy steel: AMS 6322 (8740) for applications to 550°F
Corrosion-resistant steel: AMS 5628 (Type 431) or equal for applications to 700°F

Retainer ring:
Elgiloy: cold worked, for applications to 700°F

SPS

where reliability replaces probability

Atlanta, Ga. • Culver City, Calif. • Dallas, Tex. • Denver, Colo. • Tuckahoe, N.Y. • San Diego, Calif. San Leandro, Calif. • Seattle, Wash. • Wichita, Kans.

Circle Number 24 on Reader-Service Card

The reliability of Wallace O. Leonard products has won them a ride far toward the sun—a place as standard equipment on more than twenty of our operational missiles and satellite vehicles. Leonard products range from pressure switches to such sophisticated force balance servo transducers as LOX tank level computers, from valves to calibration systems. Put your specialized problems to the capable Leonard design-engineers—their record of achievement in development is written in the successes of the new space age.

WALLACE O. LEONARD, INC.

373 SOUTH FAIR OAKS AVENUE, PASADENA, CALIFORNIA • TELEPHONE MURRAY 1-4446. TWX—PASA CAL 7321.
EASTERN REPRESENTATIVES: BRIERLY, DAVIS COMPANY—332 SPRINGFIELD AVENUE, SUMMIT, N.J.
TELEPHONE CRESTVIEW 3-7300. TWX—SUMMIT NJ 355

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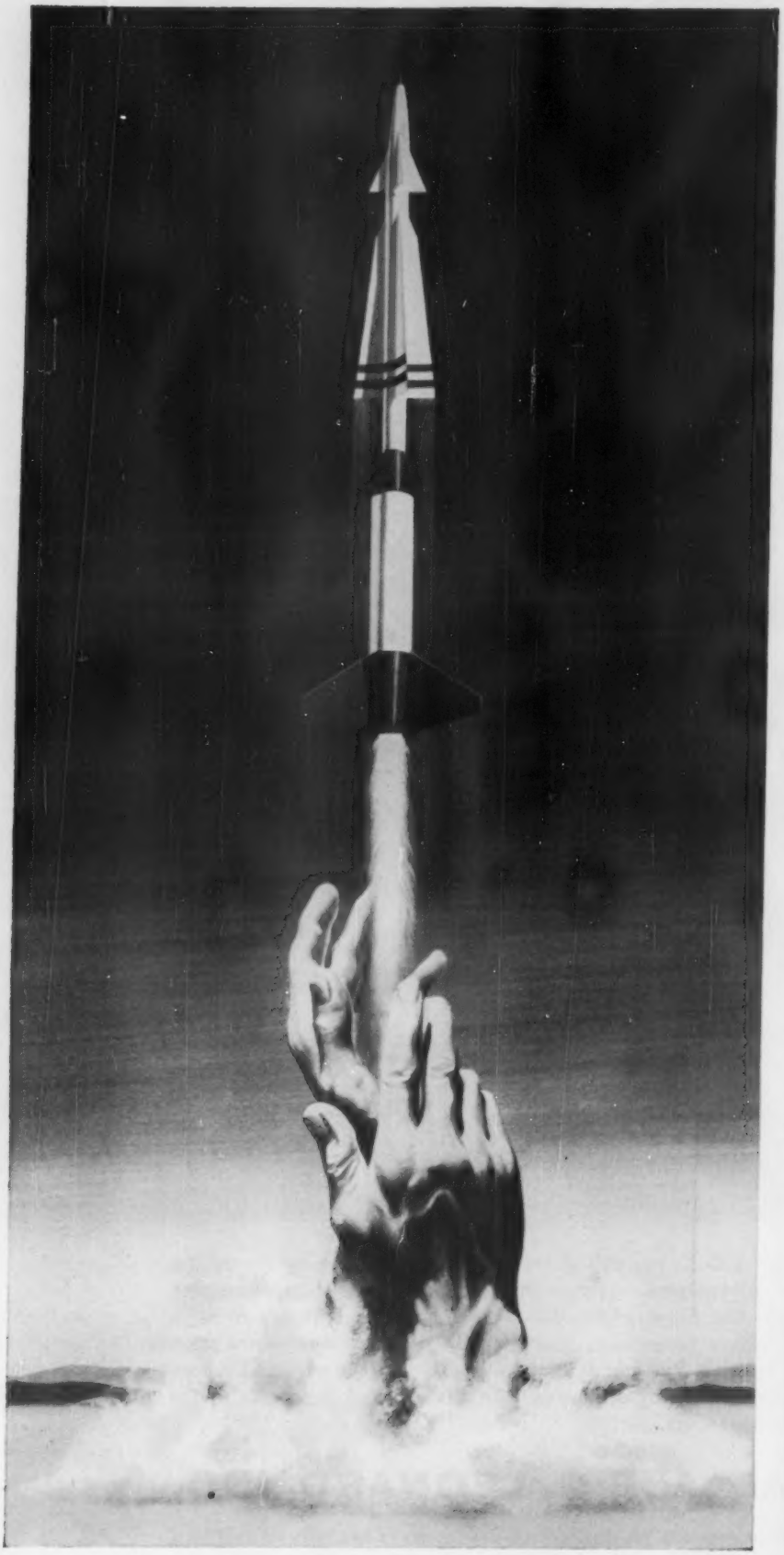


rockets and missiles

Componentry capabilities of the Kelsey-Hayes Company as a supplier of precision propulsion assemblies, structural parts and exotic high temperature materials for first and second generation rockets and missiles include—
Swivel nozzles, hydraulic control systems and auxiliary power supply systems for thrust vector control; weldments, rocket and combustion chambers for liquid and solid propellant propulsion systems; inner cones, exhaust cones, rotating wheel assemblies; vacuum induction melted alloys to withstand corrosive and extremely high temperature atmospheres; advanced design, research and development in gas dynamics, internal ballistics, transient heat and thermal stress analysis.
Kelsey-Hayes Company,
General Offices: Detroit 32, Michigan

KELSEY-HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.

Circle Number 26 on Reader-Service Card

EXCLUSIVELY FROM CANNON

A MINIATURE GENERAL PURPOSE PLUG FEATURING ONE RECEPTACLE TO ACCEPT EITHER BALL OR BAYONET LOCK PLUG... WITH HIGH ALTITUDE PERFORMANCE—Now you can get true high-altitude performance in a miniature general purpose plug! Plus, Cannon's KQ/KR *exclusively* provides one receptacle to accept either ball or bayonet lock coupling device. The KQ/KR is the latest Cannon contribution in miniature plugs... crimp-type snap-in contacts... probe-proof socket contacts... moisture sealing grommet... field service with a simple hand tool! The KQ/KR is another reason why you should consult the first name in plugs—why you should always consult Cannon for *all* your plug requirements. Write for further information on the KQ/KR, or any Cannon product.

CANNON PLUGS

Out of Space Age achievements by Government and Industry will come better living for everyone

Someday soon the art of weather forecasting will become more precise as the result of a network of meteorological satellites. Even weather *control* may become possible.

The first of these satellites, *Tiros I*, is already transmitting pictures of weather around the world. The booster that helped put it in orbit was a modified version of the reliable Douglas *Thor* IRBM. *Thor* is prime booster in the scientific "Discoverer" firings . . . has worked perfectly in over 85% of its space missions.

Thus the knowledge gained through the development of missiles has a useful peaceful application through NASA projects.

Thor is one more proof that Douglas' extensive experience in missiles is a national asset, and that nothing can substitute for the imagination, experience and skills which Douglas has accumulated in nearly 20 years of missile development.

TIROS (Television Infrared Observation Satellites) would serve weather observers—relaying information on cloud cover, temperatures, solar radiation

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • AIRCOMB® • GROUND SUPPORT EQUIPMENT

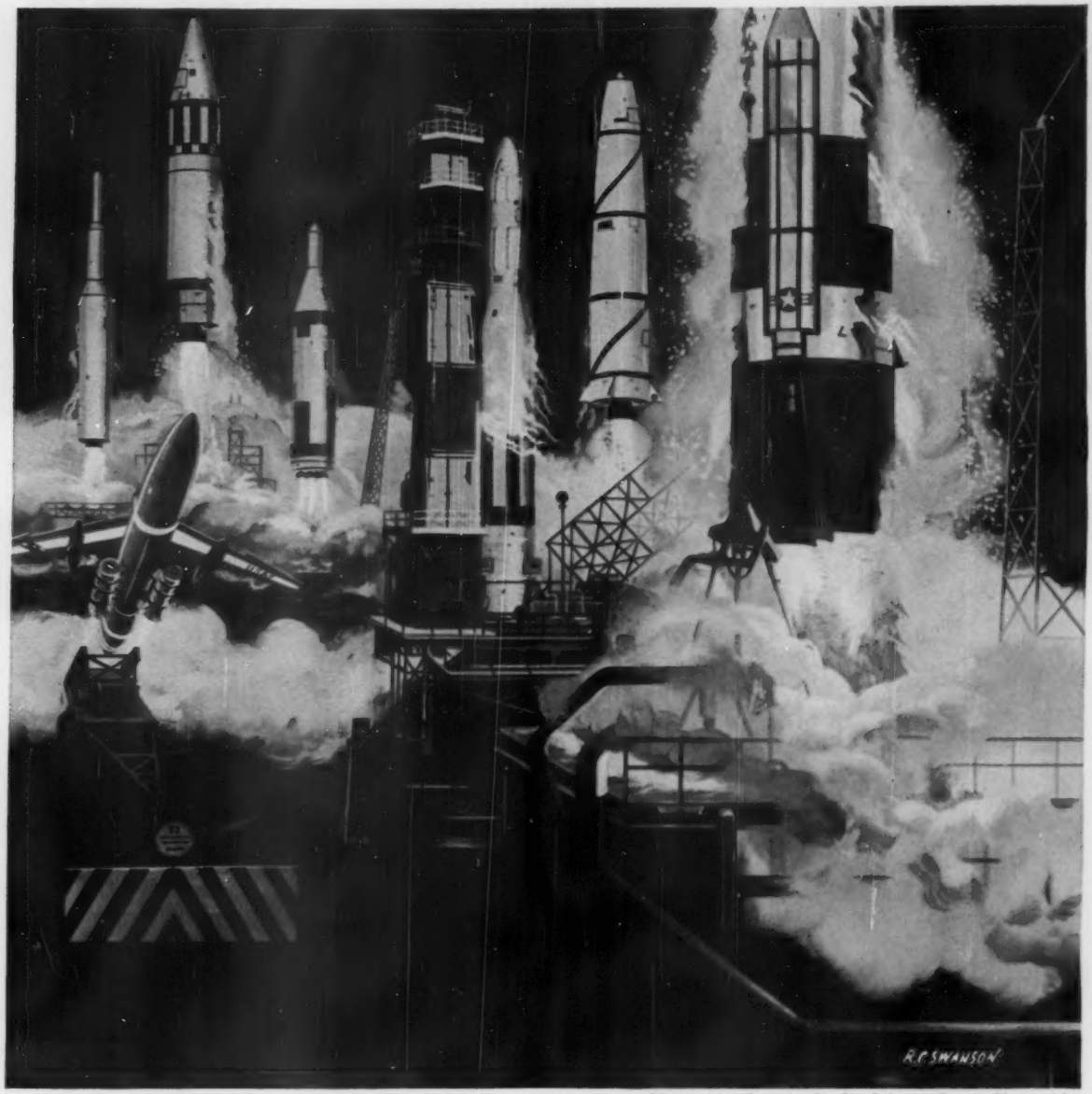
Eastern Stainless meets deadline on rework job at Douglas Aircraft

Planes were flown to the Douglas plant where passenger floors and lightweight floor beams were entirely replaced with new rugged structure to withstand heavy cargo loads. On each plane, both passenger door openings were enlarged to form cargo doors. Part of this assembly-line operation involved Type 347 stainless steel which Douglas needed in a hurry. Eastern was asked to supply the required stainless on a rush basis.

Given top priority at Eastern Stainless, the order arrived at Douglas within the allotted time enabling the project to proceed on schedule.

This is another example of the importance of stainless steel to West Coast companies—and the service Eastern Stainless offers the aircraft, missiles and rocket industry in that area. If your problem is one of tonnages, time or technical advice, talk to Eastern Stainless (or one of their good West Coast Distributors).

ES EASTERN STAINLESS STEEL
BALTIMORE 3, MARYLAND



Minuteman • Jupiter • Snark • Polaris • Titan • Thor • Atlas

ORDEAL BY ROCKET FOR SPACE-AGE BEARINGS

Successful missile firings depend on split-second operating precision in all moving parts. Achieving this calls for antifriction engineering of the highest standards . . . and for bearings that continue to operate smoothly and reliably under the toughest stress conditions wherever they may be encountered.

Development of high performance bearings for the space age is an important part of Torrington's research program. Working in close cooperation with missile manufacturers, Torrington engineers have already produced needle bearings capable of operating efficiently at 800°F. New bearing designs and materials are currently being tested at temperatures of 1200°F and beyond.

In helping missiles to fly better, more reliably and more accurately, Torrington Bearings are playing a pioneering role in the space age. It is only one part of Torrington's continuing effort to improve bearings in design, material and performance.

THE TORRINGTON COMPANY

Torrington, Connecticut • South Bend 21, Indiana

PROGRESS THROUGH PRECISION—IN BEARING DESIGN AND PERFORMANCE

Circle Number 30 on Reader-Service Card

Only the C-130 paradrops 'dozers and graders

...to clear its own landing strip

The C-130 was designed for the rough-and-ready realities of military airlift, built to land on improvised strips near the front. But there are jungle glades and mountain meadows too short and too rough for even the C-130. That's when the call goes out for a bulldozer—and a C-130 to drop it.

For the C-130 was also built to paradrop practically anything. From the giant 9 x 10 foot door beneath its upswept tail, it can float the largest tractors, trucks, and tanks down to earth.

It takes a minimum of bulldozer work to make an "airhead" for a C-130. Uproot a few trees, scrape off a few high spots and fill a few potholes, and you've got a terminal for transocean non-stop flights that average 370 mph, carry 20 tons of cargo or 92 combat-ready troops.

Another reason why the Lockheed prop-jet C-130 HERCULES provides more Jet Age airlift per dollar than any other plane now flying, now being produced, now scheduled for production.

LOCKHEED | **GEORGIA DIVISION**

OTHER LOCKHEED DIVISIONS: CALIFORNIA • MISSILES & SPACE • LOCKHEED ELECTRONICS CO. • LOCKHEED AIR TERMINAL • LOCKHEED AIRCRAFT SERVICE • LOCKHEED AIRCRAFT INTERNATIONAL • LOCKHEED, S.A. • PUGET SOUND BRIDGE AND DRY DOCK CO. **LOCKHEED PRODUCTS:** ELECTRONICS • MISSILES • AIRCRAFT • NUCLEONICS • SATELLITES AND SPACE VEHICLES • ROCKET FUELS AND MOTORS • AIRCRAFT MAINTENANCE • AIRPORT MANAGEMENT • SHIPBUILDING • HEAVY CONSTRUCTION • STEEL FABRICATION AND CRANES

NEW LIGHT ON RELIABLE DRIVE SYSTEMS

Go potential and grow potential, basically, are what make the Army's ***H-23D's*** *entire drive system a valuable investment in helicopter technology and production.*

GO*—the entire system is rated for 1,000 hour life between major overhauls by both the U. S. Army and the Bureau of Aeronautics. Army H-23D Ravens, currently logging more than 7,000 hours per month at Camp Wolters, alone, are the first light helicopters ever to receive such confidence of the Military.*

GROW*—because the H-23D's drive system is presently loafing, the limits of its growth and development lie in helicopters yet to come—helicopters that will bring even further economies of production, integration and operation.*

Designs are one thing. Deliveries another. Both come from

HILLER AIRCRAFT CORPORATION

PALO ALTO, CALIFORNIA • WASHINGTON, D.C.
ADHESIVE ENGINEERING DIVISION, SAN CARLOS, CALIFORNIA

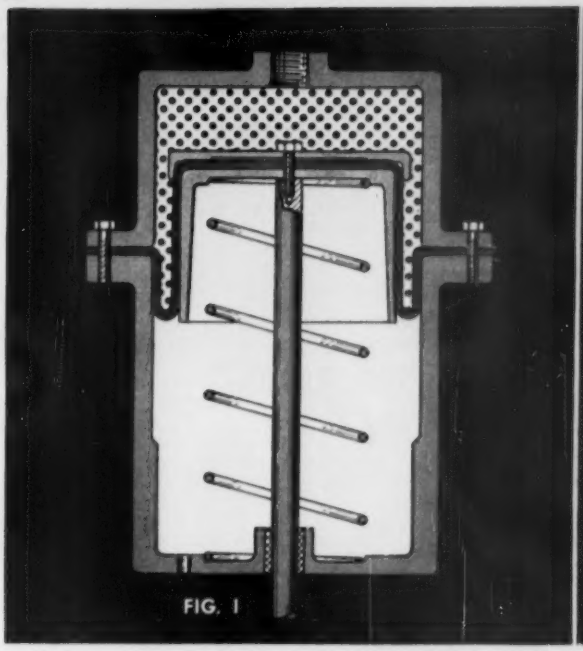


FIG. I

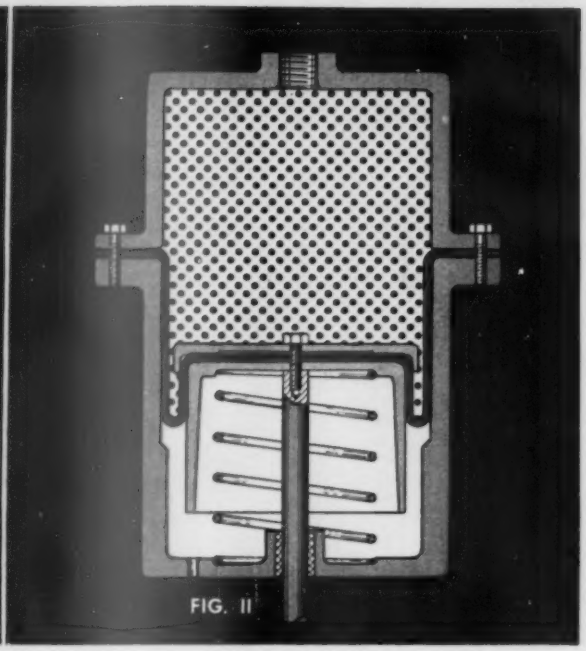


FIG. II

For Hydraulic and Pneumatic Devices

Nothing rolls like a Bellofram®

Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultra-sensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible, thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the Bellofram Rolling Diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, and fluid dampers.

Which of these advantages are you looking for?

To the designer confronted with situations for which conventional bellows, O-rings, or cup packings are inadequate, Bellofram Rolling Diaphragm offers a constellation of advantages found in no other product:

1. **Friction-free (low hysteresis).**
2. **No break-out friction effects.**
3. **Non-porous and leakproof.**
4. **Constant area in all piston positions.**
5. **Almost infinite flex life (millions of cycles).**
6. **Sensitivity to extremely small pressure changes.**
7. **No mechanical spring gradient.**
8. **Compatibility with practically all environmental gases or fluids.**
9. **Automatic de-icing action.**
10. **Free positioning with complete relaxation at any point in the stroke.**
11. **Does not require close machine finish tolerances on pistons and cylinders.**
12. **Freedom from abrasive wear.**
13. **One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.**
14. **Excellent temperature stability from —85°F. to 550°F. (from —120°F. to 700°F. in some cases). Wide range of working pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases). Effective pressure areas from .028 to 108 square inches. Cylinder bore diameters from .25 to 12 inches. Extended range of stroke (.01 to 12 inches).**

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Bellofram Rolling Diaphragms are protected by U.S.A. and foreign patents.

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Bellofram Corporation, 34 Blanchard Rd., Burlington, Mass.

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for the MARTIN COMPANY,
Prime Contractor for the
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For detailed information about SIE telemetry, signal conditioning systems, please contact LIGHT MILITARY PRODUCT MANAGER

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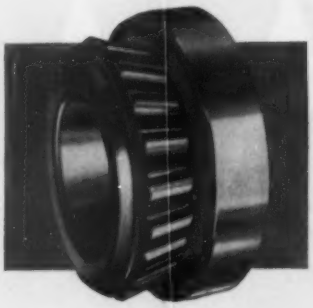
To roll the load surely, safely, on time you can depend on Bower bearings. The extra assurance, extra service they give results from definite design advantages. Spherically generated roll heads, higher flanges and larger two-zone contacts translate into trouble-free service, reduced maintenance, longer bearing life.

Whether you build, buy or maintain trucking equipment—or *any* product that uses roller bearings—ask for Bower first. You can select from a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.



BOWER ROLLER BEARINGS

Bower Roller Bearing Division • Federal-Mogul-Bower Bearings, Inc. • Detroit 14, Michigan

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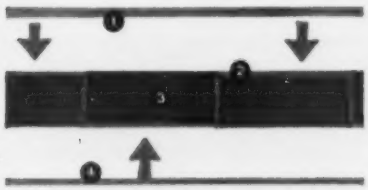
Johns-Manville Announces... MIN-KLAD INTERLOK

. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*an insulation with protective high-temperature facings.*

Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok



1) Outer facing, 2) Interlocking web, 3) Core, any one of several Min-K formulations, and 4) Inner facing.

All the above components combine to provide a custom-made structural strong insulating system.

—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JM PRODUCTS

AiResearch inboard GTP 70 gas turbine engine delivers electrical power to Air Force Boeing KC 135 Stratotanker while it's on the ground. DC control power for the turbine is delivered by the Chatham 28V20, a lightweight, fan-cooled, 20 amp selenium transformer rectifier featuring operation over a wide frequency range (320 to 522 cps).

CHATHAM T-R helps AiResearch "wake up" fuel-ferrying jet tanker

This is the AiResearch inboard gas turbine engine. It supplies the space age power which operates instruments, lights, radio, radar and cabin heaters on the Air Force Boeing KC 135 Stratotanker while it's on the ground.

AiResearch specifies the Chatham 28V20 AC to DC transformer rectifier to assist the turbine in the ground warm-up job that helps the tanker streak away with split-second efficiency on its refueling rendezvous with thirsty, far-from-home jets.

The Chatham 28V20 delivers DC power to the turbine generator for all control functions. The converter also supplies the power to recharge the turbine engine battery, which supplies the starting power for the AiResearch equipment.

Satisfying rigid specifications and critical performance levels for missiles, jet aircraft and commercial airliners is second nature to Chatham. That's because Chatham maintains complete control of every step in the production of power conversion equipment. For example, by producing its own solid-state elements — whether silicon, germanium or selenium — Chatham designers are not limited by the "specs" of commercially available components. By strictly controlling component dimensions and reliability, Chatham keeps size and weight to a minimum, while satisfying precise electrical requirements.

Send for Chatham brochure T-26 which shows many existing transformer-rectifier units. Or, outline your needs and Chatham will recommend an original design to do the best job for you. Chatham Electronics, division of Tung-Sol Electric Inc., Livingston, N. J. TWX:NK193.

CHATHAM . . . *world's leading supplier of airborne power conversion equipment.*

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division of
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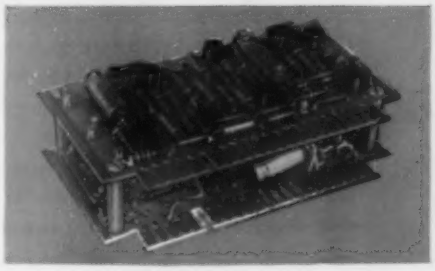
TAPCO ANALOG COMPONENTS

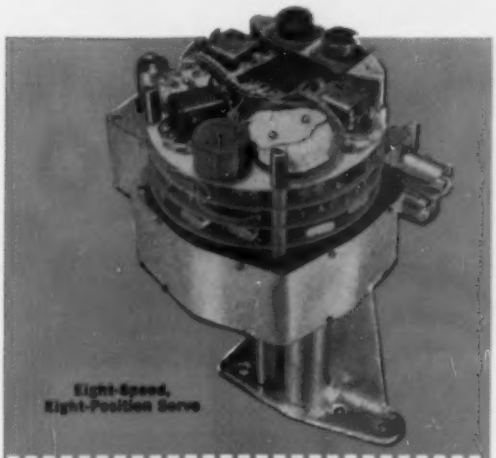
For airborne equipment

TAPCO analog components have been proved in various classified aircraft and missile applications. The TAPCO line includes:

- Position Servos
- Velocity Servos
- Miniaturized Servo Amplifiers
- Tracking Computers
- Data Conversion Units
- Arithmetic Computers



Transistorized Servo Amplifier



Eight-Speed, Eight-Position Servo

Computer Servo Chassis

PERFORMANCE DATA: TRANSISTORIZED EIGHT-SPEED SERVO (Illustrated at left)—**Speed Range:** From 1 to 2.5 rpm. **Speed Tolerance:** ±0.2% over temperature range of 50°F to 85°F. **Angular Vibration Tolerance:** 5 x 10^{-5} radians double amplitude. **Acceleration:** Zero to maximum speed within 0.2 seconds. **Transition time:** Speed change time within 0.1 seconds. **Torque Output:** 100 oz. in. with 15 watts input. Higher torque available with increased power consumption. **Power Requirements:** 10.0 watts steady rate. 18 watts peak during acceleration or speed change. **PHYSICAL DATA—Size:** 10¾" x 7¾" x 8½". **Weight:** 5¼ lbs.

For ground support equipment

All TAPCO GSE analog computer components use MIL-approved parts for highest reliability. Modular construction of these components allows compact assembly on chassis. The TAPCO line includes: DC Operational Amplifiers, Servo Amplifiers, Buffer Amplifiers, Electronic Modulators, Position and Rate Servos, Vector Servos, Aircraft Dynamic Simulator, Coordinate Converters, Special Multipliers and Dividers, Ballistic Computer.

PERFORMANCE DATA: DC OPERATIONAL AMPLIFIER—Gain: 10^6 open loop at 0.01 cps. **Drift:** Less than 100 micro-volts. **Linearity:** ±.1% of input voltage. **Input Power:** 25 watts. **Output Voltage:** ±85 V DC—50K Load, ±40 V DC—8K Load. **Noise:** Less than 100 micro-volts. **PHYSICAL DATA—Size:** 4" x 8⅜" x 2½". **Weight:** 9 oz.

PERFORMANCE DATA: AC SERVO AMPLIFIER—Gain: Open loop 60,000. **Gain:** With external feedback 10,000. **Input Impedance:** Greater than 1 megohm. **Frequency Response:** To 40 cycles. **Input Power:** Approx. 40 watts. **Output Power:** Approx. 6 watts. **High Impedance Servo Motor Output. PHYSICAL DATA: Size:** 5" x 7" x 3⅜". **Weight:** 11 oz.

For further information, write on your company letterhead to:

TAPCO GROUP EXPORT REPRESENTATIVE:
AMERICAN AVITRON, INC., MAMARONECK, N. Y.

TRW

TAPCO GROUP
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This extensive completion program at AiResearch Aviation Service for Grumman's new prop-jet corporate transport includes: custom business interiors . . . soundproofing . . . radar . . . radio . . . autopilot . . . instrumentation . . . paint . . . maintenance.

AiResearch personnel have been factory trained for this special program. Expert craftsmen utilize the newest materials and processes in building and installing lightweight, fully stressed furniture, lounges, galleys, lavatories and other appointments custom designed for the individual Gulfstream purchaser.

Our acoustical engineers have developed three individual degrees of soundproofing installations for the Gulfstream to insure the comfort level you desire. And our highly experienced, well-equipped radio and electronics departments design and execute the most modern installations.

By using a full-scale mockup of the fuselage section we are able to prefabricate components for the Gulfstream to expedite delivery time. And AiResearch guarantees the completion weight of your aircraft.

AiResearch has more experience in pressurized aircraft than any other modification center.

Write, wire or telephone for complete information, including brochure, on the AiResearch Completion Program for the Grumman Gulfstream.

Grumman Gulfstreams undergoing a custom tailored completion program at the AiResearch Aviation Service Company facility.

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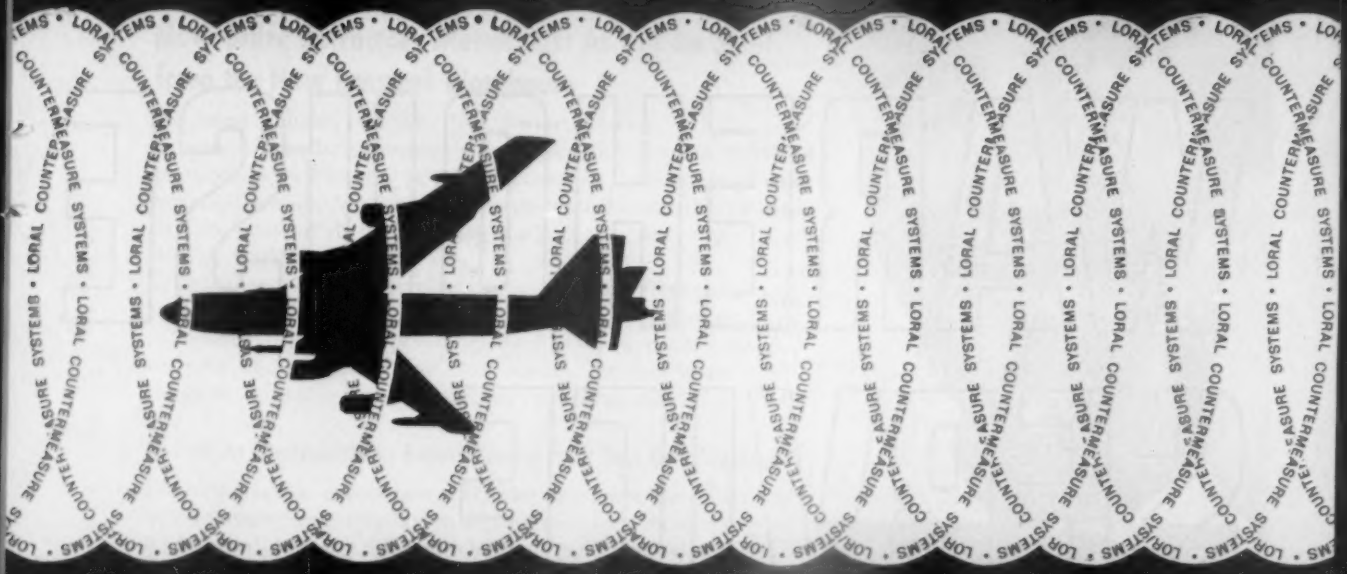

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All of These, Now Ready for Shipment

... and more types and sizes added to stock every day—

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Sheet from .005 x 10 x 156" to .125 x 12 x 12"
Foil from .00055 x 10 x Coil to .004 x 10 x Coil
Rod and Wire from .002" to .750"

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FANSTEEL METALLURGICAL CORPORATION
North Chicago, Illinois, U. S. A.

FANSTEEL

Circle Number 43 on Reader-Service Card

INERTIAL COMPONENTS

SUB-SYSTEMS AND FLIGHT TEST EQUIPMENT

RATE GYROSCOPES

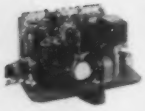
TYPE M-100 is the latest in Honeywell's family of miniaturized high performance rate gyros. It features constant damping (0.6 at −65°F) over a wide operating temperature range without the use of heaters.

TYPE GN or "Golden Gnat" is another of Honeywell's high performance gyros and has been in full production in a wide variety of miniature rate packages over the past three years.

TYPE JR, another rate gyro of proven reliability, features a unique quadrilever spring suspension for high sensitivity and a wide full range under severe environmental conditions; TYPE JRT is available with heaters for those critical applications requiring constant damping; TYPE K Rate Measuring Gyro features a linear output signal that is proportional to the input rate within 0.25% full scale.

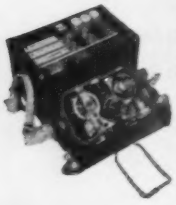
INERTIAL SUB-SYSTEMS

F-102 THREE-AXIS RATE GYRO SYSTEM Instantaneous detection of aircraft turning rates about the roll, pitch, and yaw axes is accomplished by three Model JR gyros. The resulting output signals teamed with other equipment, make possible uniform pilot control response for all flight conditions.



F-106 THREE-AXIS TURN RATE TRANSMITTER This sub-system features three Gnat miniaturized gyros that detect rate of turn about the roll, pitch, and yaw axes and responds with an output signal to provide polarity reversing D-C outputs proportional to the corresponding input rate.

CONTRACT ENGINEERING AND MANUFACTURING



Honeywell's Boston Division will design from customer specifications or prototypes, or manufacture to customer's drawings. Typical of the completed programs in this area are: CN-100 Compass-controlled Stable Reference Platform for a bombing system (shown at left), and Displacement Gyros for the A1A/BNC Bombing Navigational Computer.

ACCELEROMETERS

TYPES LA-100, LA-300 are low cost, rugged, linear, non-pendulous units with potentiometer outputs.

TYPE LA-200 is a miniaturized, pendulous, linear accelerometer which is fluid-damped and mechanically compensated. Output signal is provided by a variable reluctance signal generator.

TYPE LA-500 is a linear, non-pendulous, fluid-damped potentiometer output device that features constant damping, linear response, (−65° and +175°F).

TYPE LA-600 is a linear, non-pendulous A-C accelerometer in which pick-off friction is eliminated to permit resolution of extremely low level inputs. This accelerometer features magnetic damping for near constant damping ratio (−65°F to +250°F).

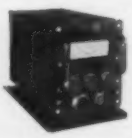
TYPE LA-700 linear, non-pendulous accelerometer is a complementary unit to the LA-600 for those applications requiring a high full-scale range combined with a low natural frequency.

TEST EQUIPMENT

HONEYWELL RATE GYRO TEST SET designed for use by field personnel for the static analysis of rate gyros, rate gyro demodulator amplifier, and three-axis rate gyros packages. This equipment meets the design requirements of MIL-T-945 and environmental test requirements outlined in MIL-E-4970.

SPECIALIZED TEST EQUIPMENT such as Radar Range Servo Test Sets, Frequency Response Analyzers, and other electronic equipment can be designed and manufactured to meet your requirements.

FLIGHT TEST EQUIPMENT



TYPE DV-4 POWER SUPPLY-DEMODULATOR (115 volt, 400 cycle, single-phase primary power available) energizes 1 to 3 Honeywell Rate Measuring Gyros, Type K, and translates the gyro output signals to a form suitable for use with recording oscillograph galvanometers or tape recorders.

Write to Minneapolis-Honeywell, Boston Division, Dept. 11, 40 Life Street, Boston 35, Massachusetts.

75th YEAR — PIONEERING THE FUTURE

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Military Products Group — SINCE 1885

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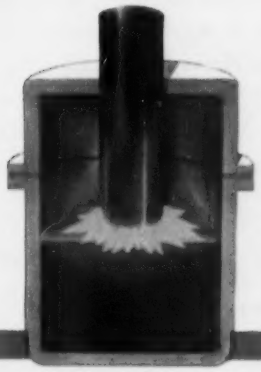
WHEN MAXIMUM RELIABILITY AND MINIMUM REJECTS ARE REQUIRED

SPECIFY MIDVAC STEELS



Simplified illustration of Midvac Process of consumable electrode vacuum melting.

Fine electric furnace steel electrodes are melted in water cooled copper ingot mold under vacuum of 5 to 50 microns

• Midvac Steels Are Produced By The Midvac Process Of Vacuum Consumable Electrode Melting

• Midvac super alloy and high strength steels are being used for highly critical parts in jet engines, missiles, bearings, reciprocating engines and places where high reliability is a "must". The Midvac Process of consumable electrode melting eliminates atmospheric contamination, ingot soundness is improved, segregation is reduced, workability is increased and rejects are held to an absolute minimum. M-H metallurgists are ready to help you select the right alloy to meet the specifications of your product. Write to **Midvale-Heppenstall Company**, Nicetown, Philadelphia, Pa. Subsidiary of Heppenstall Co., Pittsburgh, Pa.

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- Stress rupture hours increased from 15 to 100 hours.
- Improvement in macro etch quality

SHAFT

- Meets higher specifications
- 33% Increase In Elongation
- 38% Increase In Reduction of Area
- Improved Forgeability and Fatigue Strength

BEARINGS

- Rejects Reduced 73%
- High Level of Cleanliness
- Increased Fatigue Strength

TURBINE ROTOR

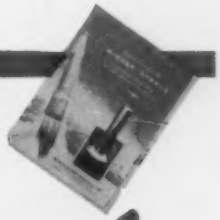
- Improved Tensile Ductility, Lower Transition Temperature, Higher Impact Strength
- Higher Magnetic Permeability
- Longer Stress Rupture Duration

ROLLS

- Polished In ½ to ⅔ Time Previously Required
- Finer Lustre On Finished Product Due To More Uniform Grain Structure

ROCKET MOTOR CASE

- Maximum Cleanliness
- Higher Ductility
- Improved Shear Forming



New technical data book on Midvac Process and properties of super alloy steels, melted by consumable electrode vacuum melting, now available upon request.

MH

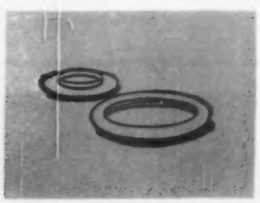
Midvac Steels

Garlock's unique position in the missiles industry . . .

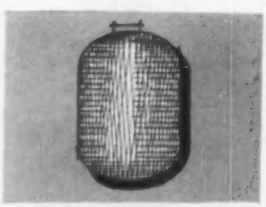
may be of infinite value to you. *Acceptance:* Right now Garlock is supplying rocket motor components for various phases of development and production of seven different missiles. *Flexibility:* Garlock has the people, the equipment, and the experience to swing into prototype production on short notice, and to follow this with full-scale production as needed. *Diversified Abilities:* Garlock is thoroughly familiar with the design and manufacture of components from a wide range of basic materials—metals, rubber, phenolics, fluorocarbons and other plastics. *Completely Integrated Staff:* Garlock's product design, tool design, pilot manufacturing and production staffs are completely integrated for efficient handling of a project from start to finish. Garlock engineers will work to your design—or with you in developing designs. Write or call Military Products, Garlock Inc., Palmyra, New York.

GARLOCK

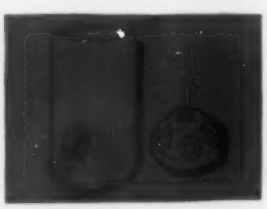
MISSILE PARTS FROM INERT MATERIALS include newly developed asbestos-phenolic compound for nozzles . . . nose cones of fluorocarbon plastics.



GARLOCK METAL FITTINGS FOR ROCKET MOTOR CASES such as blast tube and thrust terminator support rings are machined to extremely close tolerances. Made from special materials affording minimum weight, maximum strength and rigidity.



FILAMENT WOUND ROCKET MOTOR CASES made by exclusive Garlock method results in structure much lighter and stronger than steel.



INSULATION FOR SOLID FUEL ROCKET MOTORS made by Garlock is rubber-like compound which encounters gas velocities of Mach 3, temperatures to 5500° F, prolonged ambient temperatures of 300° F.

Garlock components are presently used in the development and production of:

Vanguard • Super Vanguard • Minuteman
Nike Hercules • Super Tartar • Terrier • Polaris

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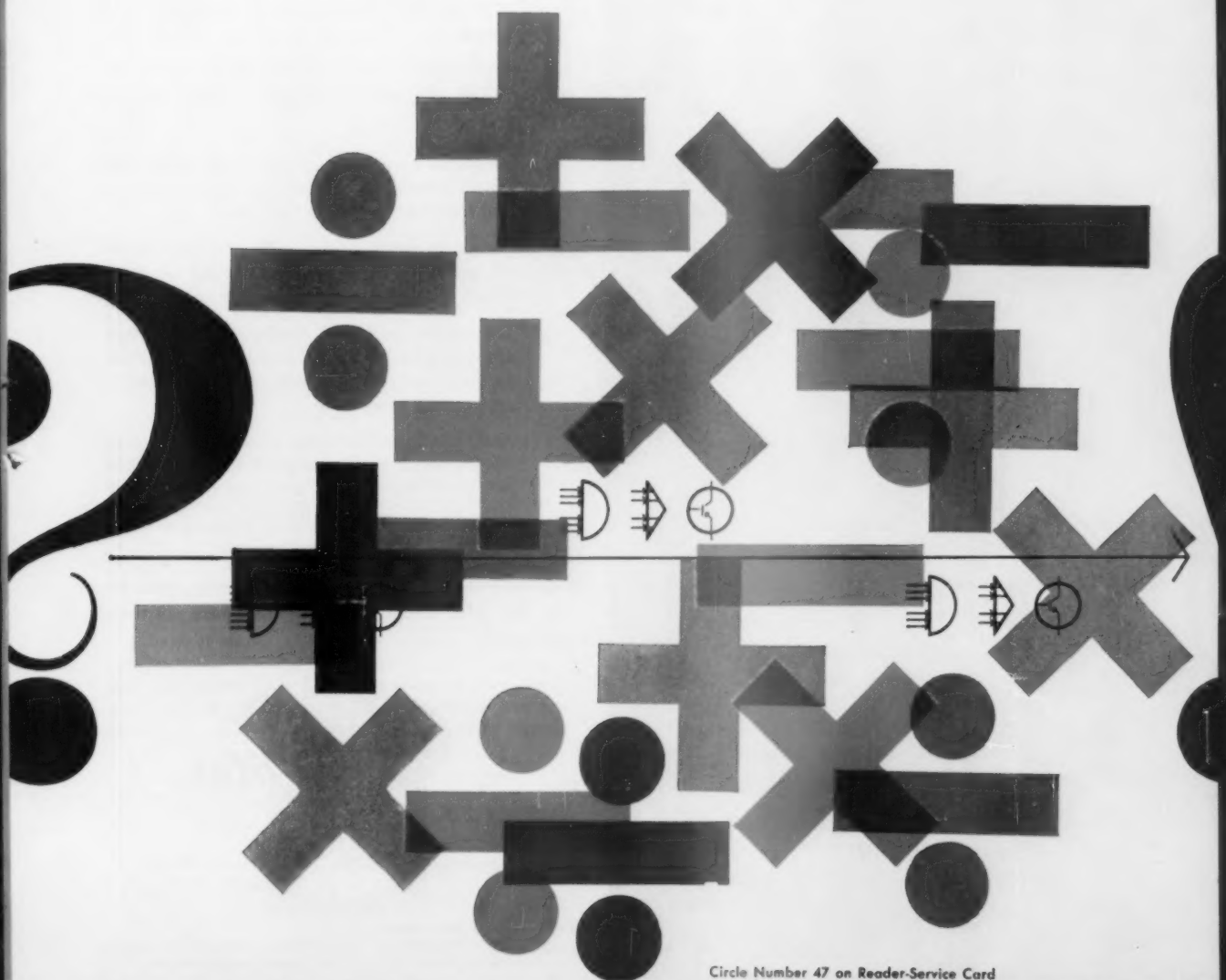
COMPUTENCE

total competence in computation and data processing—the breadth, the brains, and the background

The term: the essence of Burroughs Corporation, expanding the meaning of computation to new and unique dimensions for the contract team program and airborne, space, surface and underwater systems. **Its breadth:** total competence, ranging from basic research through production to the broadest field service support. **Its background:** total competence, from 75 years devoted to computation and data processing; from membership on the Polaris and Atlas teams, system-management of the ALRI team. **Its brain-children:** current crop includes the Atlas guidance computers, high-speed data processing for Polaris and miniaturized airborne computers for ALRI. **The point of purpose:** "Computence"—total competence in computation and data processing, closing in on a problem with an intensity and range all its own.

Burroughs Corporation *"NEW DIMENSIONS / in computation for military systems"*



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From tow targets to target missiles...
From underwater bogeys to helicopter systems...

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Today, operational interceptor squadrons all over the free world rely on Del Mar weapons training systems. Having taken its place among the foremost military prime contractors, this vigorous young company is uniquely qualified to assume further R&D responsibility in broad new areas of study and development.

Alert to the training requirements of new weapons systems, Del Mar offers an R&D capability that is built upon:

(1) An engineering and scientific staff of international reputation in advanced system studies and weapons system development

(2) Management personnel with extensive backgrounds in the employment of current weapons systems in both combat and training

(3) Laboratory facilities conducive to creative work backed up by complete production facilities for the support of developmental and testing programs

(4) And, finally, a company historical record of having successfully designed, developed, and produced operational weapons training systems during the past decade.

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ENGINEERING LABORATORIES

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Los Angeles 45, California

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TO PREDICT VIBRATION BEHAVIOR

. . . rely on the dynamic analysis capabilities of Allied Research.

Considerable accomplishments in vibration research and engineering assure reliable prediction of the shock and behavior of complex systems and sub-assemblies — *before* model construction is undertaken. Dynamic analysis pinpoints potential problems in the design stage. Necessary design modifications can then be made before the prototype is built — at substantial savings in time and money.

At Allied Research, dynamic analysis considers every facet of the system or assembly to be produced. This includes an examination of structural characteristics, studies covering the nature of vibration inputs, determination of resonant frequencies under every operation, and prediction of vibratory stresses and the system's susceptibility to fatigue from repeated accelerations. Analytic techniques and evaluations of dynamic models enable Allied Research engineers and designers to effect prompt detection and correction of trouble spots.

Investigate Allied Research's broad capabilities in vibration research and development — analysis, design, testing and equipment manufacturing. Write today for advice and assistance on specific problem areas.

Allied Research offers immediate key career opportunities in 10 technological fields to scientists and engineers. For full information, forward your resume in complete confidence. A booklet describing Allied Research facilities and capabilities is also available on request.

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A BOEING SUBSIDIARY

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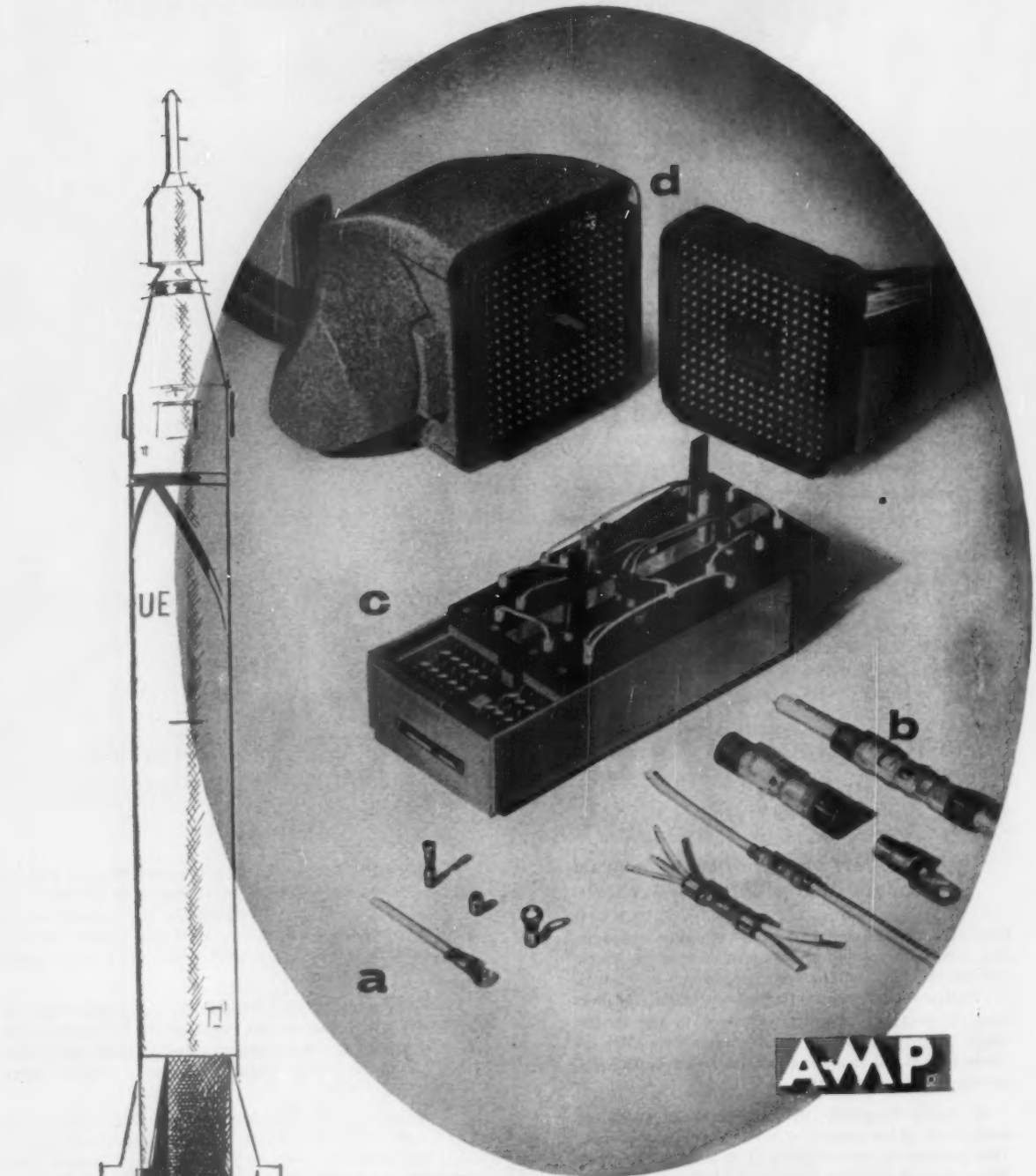
because CIRCUIT



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RELIABILITY is Vital...

. . . AMP's product is more than fine circuit terminals . . . more than remarkably precise compression-crimp tooling . . . more than an error free, fast method of attachment.

AMP's product is finished crimp-type terminations on your circuitry wires . . . by the hundreds or millions . . . of the highest reliability . . . performing under gruelling conditions . . . from basic terminals to complete patchcord systems.

Listed here are a few of the more than 15,000 circuitry items that AMP INCORPORATED has developed.

a STRATOTHERM TERMINALS AND SPLICES FOR APPLICATIONS WITH CRITICAL THERMAL FACTORS

- up to 1200°F. operating temperature
- solid, stranded or combination conductors
- shock and corrosion resistant
- wire size range 22-10 AWG
- serrated inner barrel for maximum tensile strength

b CERTI-SEAL AND Ampli-NYL SPLICES

- combined wire size range 22-2/0 AWG
- exceed millivolt-drop specifications
- finest nylon pre-insulation
- shock and corrosion resistant
- color coded by wire size

c A-MP PATCHCORD PROGRAMMING SYSTEMS AND PANELS FOR COMPUTERS, TELEMETERING EQUIPMENT AND AUTOMATION ("240" Airborne Unit illustrated)

- universal or shielded systems
- patented wiping action pre-cleans pins and contact springs
- nylon sleeve insulates and firmly seats patchcord pin in board
- contacts have rear board accommodation for taper pins to provide reliable solderless lead terminations

d 200 CONTACT CABLE CONNECTOR FOR CRITICAL MULTIPLE WIRING APPLICATIONS

- voltage rating: 1,000 volts A.C., R.M.S.; current rating in excess of three amperes
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- five indexed positions to permit strain-free cable entrance
- identical boards and contacts in both halves
- polarized to prevent improper coupling—has numbered cavities to assure proper circuit identification.

Complete information on these four product lines is available on request.

INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

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stainless steel tubing; ducting assemblies for bleed air, cooling and heating, cabin pressurization, anti-icing, exhausts, etc.; flexible ducting sections and joints; metal hose—all designed specifically for the aero/space industries and formed by exclusive methods to do more with less weight, in less space. Let the masters of precision-formed thin metals work with you on all your ducting requirements—both standard components and special engineering.

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GD700 SERIES
GAS-O-DOME REGULATORS

Models in bronze or stainless steel
Pilot operated type
Max. inlet: 7000 to 10,000 psig.
Outlet range: 10-150 to 400-7000 psig.
Flows to 250 scfm.
Low torque: 35 inch-lb. at 7000 psig.
Panel mounting
Bulletins R12 and R18.

BPR SERIES
BACK PRESSURE REGULATORS

Models in bronze or stainless steel
Adjustable relief ranges: From 25-500 psig. to 2000-10,000 psig.
Panel mounting
Bulletin R19

LR SERIES LOADER REGULATORS

Models in bronze or stainless steel
Max. inlet: 7000 to 10,000 psig.
Outlet range: 5-200 to 200-10,000 psig.
Flow: 10 scfm.
Low torque: 35 inch-lb. at 7,000 psig.
60 inch-lb. at 10,000 psig.
Panel mounting
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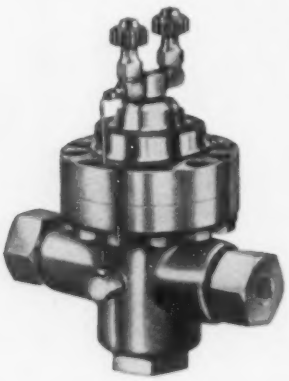
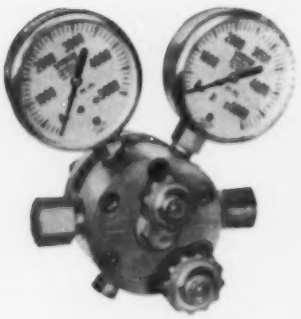


GD90, GD100A AND GD200A
SERIES GAS-O-DOME REGULATORS

Models in bronze or stainless steel
Compensated, high-flow type
Max. inlet and outlet: 6000 psig.
Flows to 80,000 scfm.
Remote control and/or
panel mounting provisions
Bulletin R18

L.-10 LOADER VALVE

Made in bronze only.
Inlet and outlet: 7000 psig.
Flow: 10 scfm.
Fast finger-tip control:
30° clockwise, loads;
30° counter-clockwise, bleed
Panel mounting
Bulletin LV-10



GD60 AND 80 SERIES
GAS-O-DOME REGULATORS

Models in bronze
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Flows to 1500 scfm.
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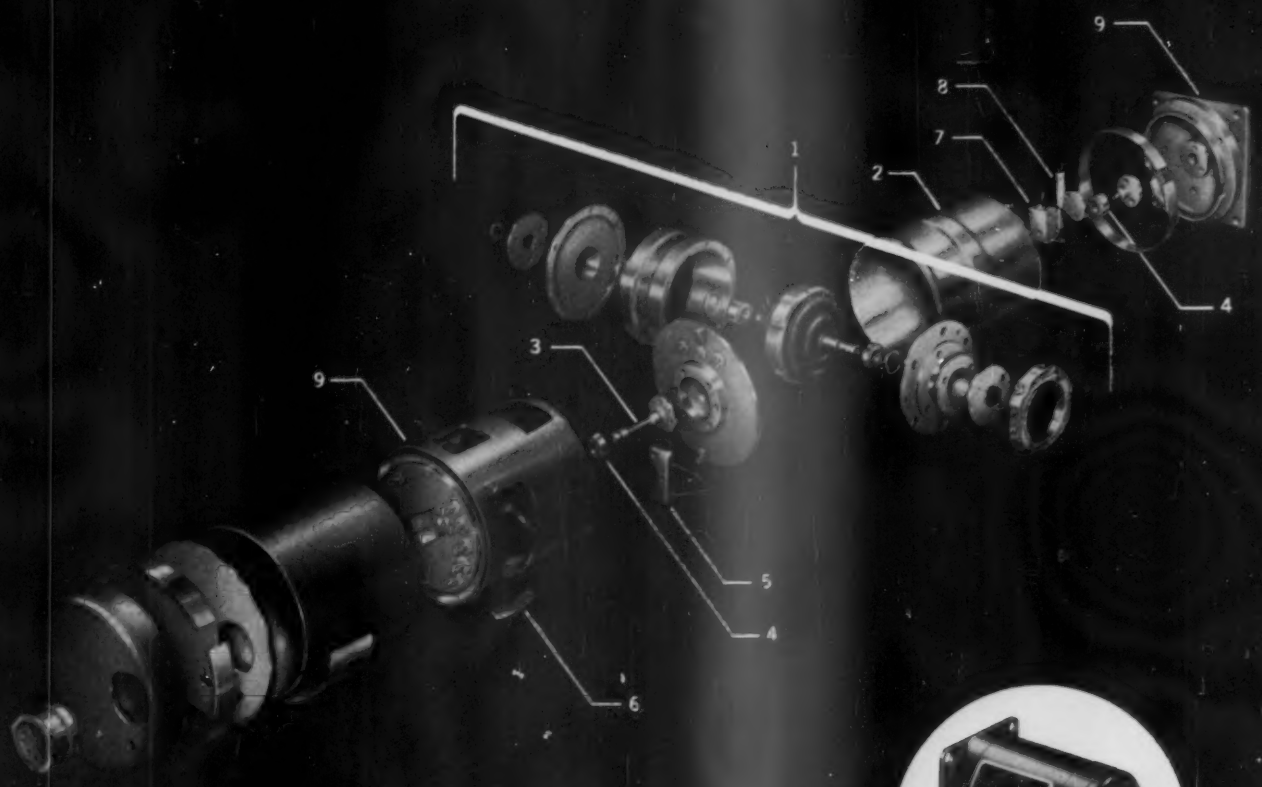

A LOOK UNDER THE COVER AT . . .

R 51 Series
Floated Rate Gyro

10 YEARS OF FLOATED RATE GYRO EXPERIENCE

OVER 40,000 AIRBORNE INSTALLATIONS—including the latest missile and aircraft programs—have consistently proved the extreme reliability of Daystrom miniature and subminiature rate gyros.

And for good reason. From more than 150 design variations, Daystrom's high-volume production capability assures that "standard" or "special" gyros can be quickly and inexpensively custom-assembled to your exact specifications. They offer either AC or DC motors, potentiometer or microsyn pickoffs and dashpot or viscous-shear damping. All models are either end or center flange-mounted, have a nominal temperature range of from —65°F to above +212°F and qualify to MIL-E-5272 or beyond. Special, continuous duty, high temperature units are available.

It's another example of Daystrom's ability to create better instruments and systems in smaller, more economical packages for military and commercial use. For complete information and specifications write for Data File AW-1151-1.

Typical of Daystrom floated rate gyros is the R 51 Series (DC Pickoff), an hermetically sealed rate gyro consisting of a **spin motor** (1) mounted on a **sealed gimbal** (2) that is **restrained** by a **torsion spring** (3). Alignment of the gimbal support is maintained by **bearings** (4) at both ends. A **potentiometer wiper** (5) is mechanically coupled to the gimbal. Precessional movement about the gimbal axis causes displacement of the wiper and this displacement is transmitted to a **potentiometer** (6). Damping is performed by two **damping assemblies** (7) with bi-metallic temperature-compensating **springs** (8). The rugged construction of the **castings** (9) assures maximum stability.

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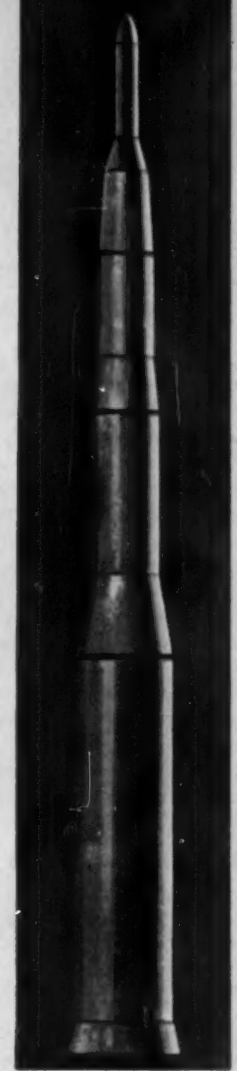

SEALED IN A SECRET SILO

Somewhere in a wasteland, the Air Force Minuteman will keep its lonely vigil all through a thousand nights. Buried and untended, it must be ready to spring to life if the button is ever pushed.

Minuteman poses a real challenge to the New Reliability—reliability which must guarantee successful firing at any moment in the far future. Each of the missile's systems, each of its thousands of electronic components, must function perfectly at that given moment. For once the missile is lowered into its silo, no human hands again need touch it.

The Minuteman's critical guidance and control system has been entrusted to Autonetics. We are proud to be a member of this United States Air Force missile team.

Once again America's defense force reaps the harvest of Autonetics' pioneering. A decade of experience with major projects has given Autonetics a unique capability in systems management—and in meshing its work with that of other companies in building modern weapon systems.

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INERTIAL NAVIGATION / ARMAMENT AND FLIGHT CONTROL / COMPUTERS AND DATA SYSTEMS

NEW e·m·r SUBCARRIER DISCRIMINATOR

ALL SOLID STATE...PHASE-LOCK-LOOP DETECTION... MINIATURE... FOR TELEMETRY AND DATA REDUCTION

MODEL 167A Solid-State Discriminator (half-rack width)

The new **e·m·r** Model 167A Subcarrier Discriminator is a precision instrument designed for demodulating FM subcarrier signals with exceptional linearity. The new Model 167A employs phase-lock-loop detection in completely solid-state circuitry to achieve outstanding characteristics of performance and durability in a miniature package. The new discriminator has a true 60-db dynamic input voltage range. Amplitude of each subcarrier signal can be as great as 5V rms in a multiplex of up to 18 subcarriers. Amplitude modulation effects such as tape dropouts are virtually eliminated by dynamic limiting, effective over a true 60-db voltage range.

The design is such that phase-lock-loop characteristics are automatically optimized regardless of channel selector used and output filter chosen. The channel selector delay network provides fine tuning to allow tape-speed wow-and-flutter compensation of better than 100:1. The Model 167A is available with all standard IRIG center frequencies, frequency deviations, and intelligence frequency outputs.

The new Discriminator is packaged in less than half-normal-panel width. Two can be mounted side by side in a 19" rack, using a simple fastener.

CONDENSED SPECIFICATIONS

Center Frequency: IRIG standard; up to 300 KC available
Frequency Deviation: IRIG standards; up to ±40% available
Intelligence Frequency Output: IRIG standards; up to 60 KC available
Input Dynamic Range: 60 db, 5 mv to 5V rms
AM Rejection: less than 0.3% peak bandwidth change for 20 db input step change
Unwanted Signal Rejection: 60 db rejection of f. s. modulation on adjacent channel having 16 db greater amplitude
Linearity: ±0.05% of bandwidth with respect to best straight line
Tape-speed Compensation: greater than 100:1 reduction of wow-and-flutter up to ±10%
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Output: cal. output control adjustable ±1.0V to ±10V at 500 ma load (to 10 kc intelligence)
Power Consumption: 30W at 120V rms.
Size: 3½" x 8" panel; over-all depth, 18"
Meters: two cal. meters provided—Subcarrier Volts and % Output

For complete information contact:

emr ASCOP

Electro-Mechanical Research, inc.

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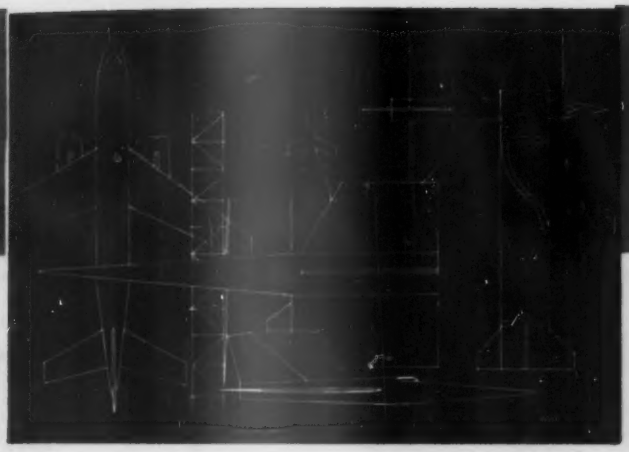
"BECCO Hydrogen Peroxide has met all performance requirements"

—[illegible] General Electric Company's Flight Propulsion Laboratory Department



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"1. Becco has met all our delivery requirements for hydrogen peroxide regardless of the size of the order.

"2. Deliveries have never failed to meet our specifications.

"3. The hydrogen peroxide delivered has met all performance requirements. Our decomposers have never failed due to trace elements in the peroxide. Our decomposers have run 67,000 seconds at a fuel rate in excess of two pounds per second without malfunction.

"4. Storage requirements have been exceeded in all cases."

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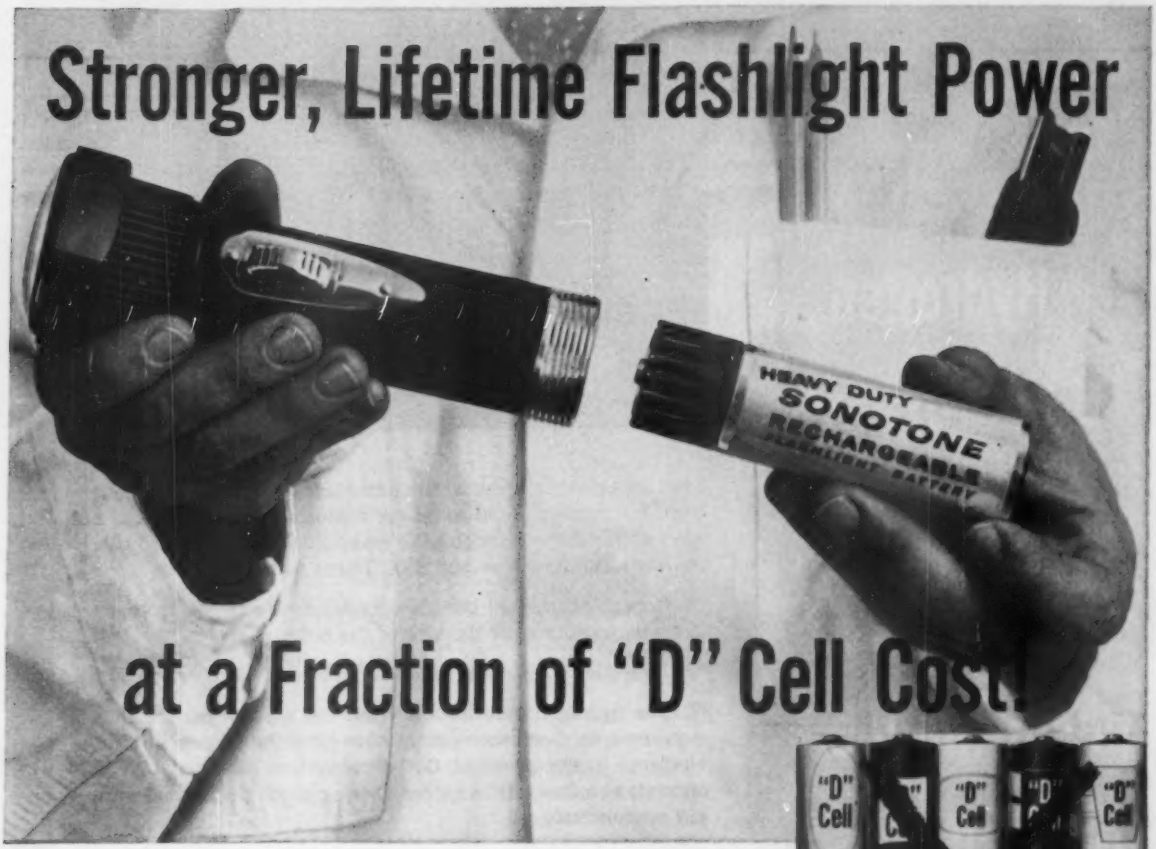
Stronger, Lifetime Flashlight Power



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To recharge, just unscrew cap...

and plug overnight into any 110-120-volt AC outlet.

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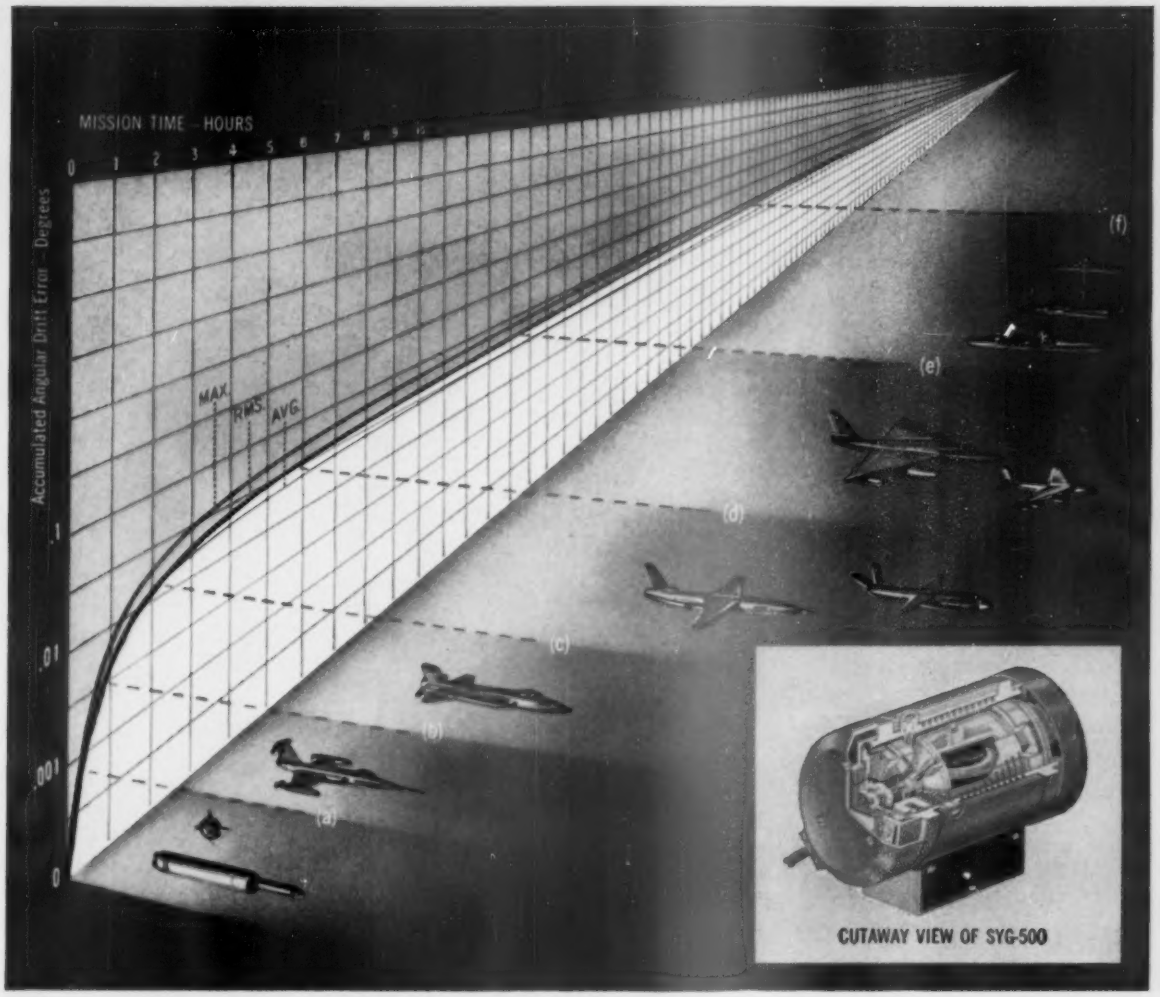

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Sperry SYG-500 FLOATED INTEGRATING GYRO offers full-mission accuracy . . . flight-proven reliability

- **New non-freezing Gyrolube™ flotation fluid**
- **Isoelastic gimbaling**
- **Long-term drift stability**
- **New long-life low-wear spin wheel bearings**

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The SYG-500 is the result of the most thorough study, analysis, evaluation, lab- and flight-testing of any floated gyro in production today. It is rugged, with full accuracy even after exposure to acceleration, vibration and impact shock (MIL-E 5272B). It is non-freezing; a new flotation fluid, Sperry Gyrolube, permitting unlimited storage between −65°F. and +180°F. without impairment of accuracy. Thermal equilibrium is rapidly attained as a result of advanced insulation techniques. New low-wear spin wheel bearings contribute to a life in excess of 3500 hours.

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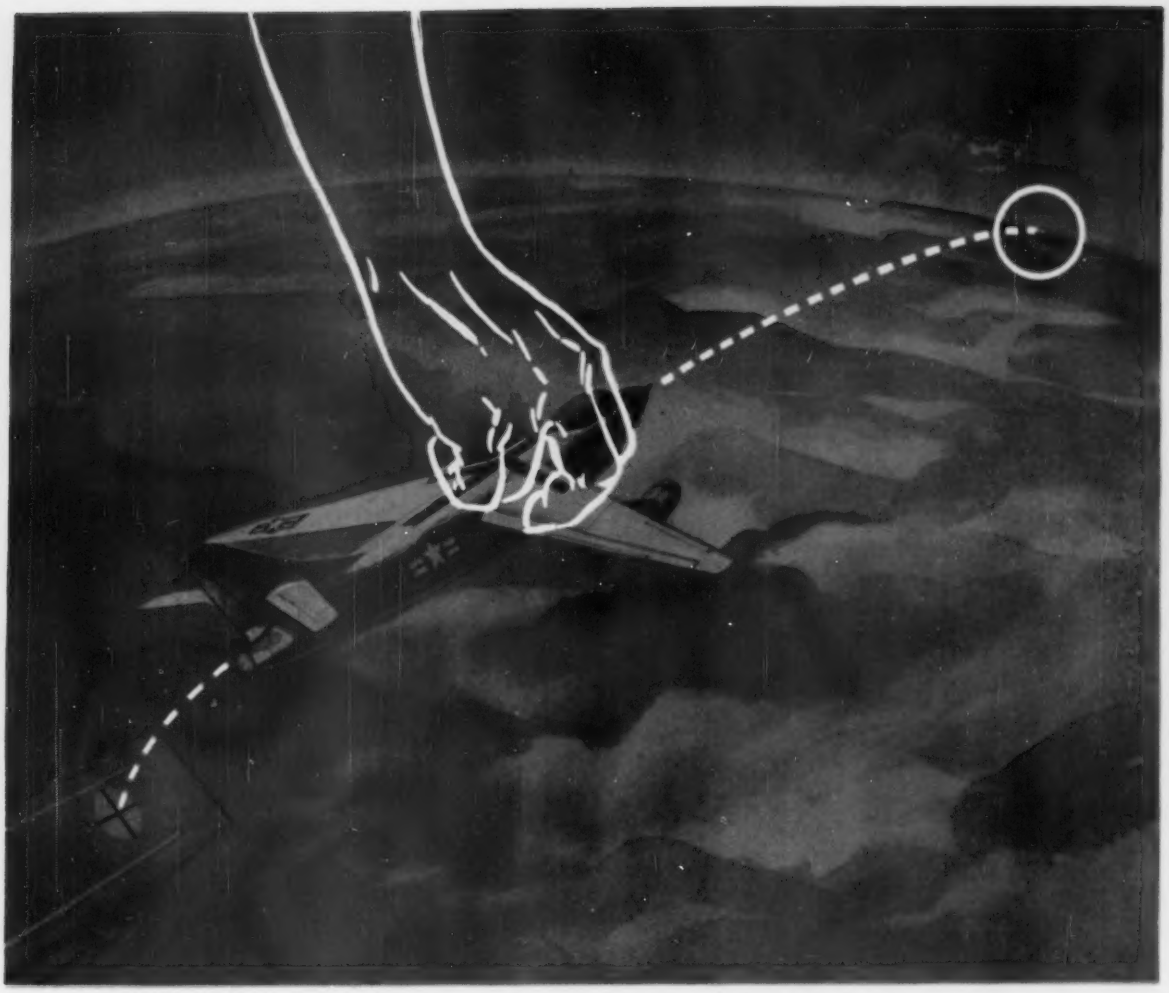

SILENT PARTNER
from take-off to target to bomb-drop and return

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02

M. Marey Monge made an attempt to keep imagination in check when he conceived this military balloon in 1800. Complete with sail, the "dream" balloon was supposed to support an army of 4,000 in every way for months at a time. In this wood engraving, Brussel-Smith has included the most minute details of Monge's ambitious project.

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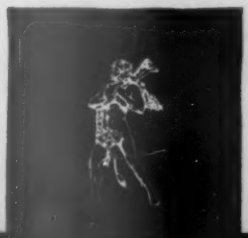

He put a new twist in an old trick

His problem was to take a 3"x6"x 3-foot piece of wave guide tubing made of .08-inch thick aluminum and to twist one end 90° to the other *without buckling or stretching any part of it...so that a cross section taken anywhere along its length remained a perfect rectangle.*

The standard solution for a problem like this: Support the tube internally with a solder-like substance that's melted in, cooled, melted out after twisting. It won't work here because the mass of the substance is too great.

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Aviation Week

and Space Technology

Vol. 72, No. 25 Member ABP and ABC June 20, 1960

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COVER: SAC maintenance personnel of the 576th Strategic Missile Squadron, First Missile Division, check the missile erector on a "coffin" launcher site at Vandenberg AFB, Calif. Missile is a Convair Atlas ICBM fitted with a General Electric Mark III nose cone. "Coffin" type Atlas launcher is an interim phase in transition from the gantry types used for SAC's first operational ICBM complex at Vandenberg to the hardened silo emplacements. Goodyear Tire & Rubber Co. is prime contractor for construction of the erection mechanism on the Atlas horizontal complex.

84,268 copies of this issue printed.

PICTURE CREDITS Cover—Richard J. Filakousky, USAF, 1352nd Motion Picture Squadron; 76, 77, 78—Aviation Week; 92—American Airlines; 93—City of Chicago; 95—Northwest Airlines; 102, 104, 105, 107, 108, 109, 110, 111, 121, 129, 130, 131, 135, 136, 137, 138, 139, 140, 142, 143, 144, 188, 189—USAF; 113-124—Convair; 115, 126, 127, 168, 319—Boeing; 123, 156, 157, 160, 163—McDonnell; 141—The Shreveport Times; 146, 147, 149, 153—D. A. Anderton; 160—J. S. Butz; 163—North American; 167, 183—Howard Levy; 170—Chance Vought; 176—Crown Copyright; 181, 183, 185—Lockheed; 191—ARPA; 200—Collins Radio; 206, 207, 209, 212—Marquardt, Lawrence Radiation Lab; 231—Avco; 256, 257—Robert Stanfield; 257—General Precision, Inc.; 265—Coffing Industries, Vecto Instrument; 272—Morane-Saulnier; 277, 280, 283—Curtiss-Wright; 284—Rhein-Flugzeugbau; 303—Grumman; 305—Garrett Corp.; 307—Martin; 311—North American Aviation, Stromberg-Carlson; 339, 341—Goodyear Aircraft.

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EDITORIAL

A New Look at SAC

Ability of Strategic Air Command to maintain its effectiveness in an era of swiftly changing technology and international relations is one of the keys to the survival of this country and its future success in maintaining world peace on terms consistent with our principles.

Development of the twin technologies of aeronautics and nucleonics and their combination in the postwar long-range bomber force of SAC provided the U.S. with a unique ability to exercise military power with hitherto undreamed of speed and scope. All of this was accomplished at the cost of an extremely small portion of the gross national income.

For 15 years, with the exception of Korea, this combination of technology forged into the military power of SAC has kept world peace. With the advantage of hindsight, although there were critics who diagnosed the situation correctly at the time, it is obvious that the Communist miscalculation to begin the Korean war resulted from two cardinal errors in our exercise of a deterrent policy. First, the then-Secretary of State, Dean Acheson, indicated in a public speech that Korea was outside the U.S. Pacific defense perimeter. Second, the then-Secretary of Defense, Louis Johnson, embarked on a program to cut U.S. defense strength to the bone. The Korean tragedy made it evident that deterrence cannot be effective unless it is wielded from a position of unchallenged military strength and unless the determination to use this strength if necessary is clearly and unmistakably evident to potential aggressors.

In the twin crisis of Lebanon and Quemoy the swift dispatch of token conventional forces to the scene of conflict was correctly interpreted as indicating the U.S. determination to use SAC if the aggression did not recede. The dispatch of these token forces would have been pointless if the shadow of SAC's potent wings had not loomed clearly behind them.

Soviet ICBM Challenge

The success of SAC in exercising an effective deterrent for the 15 years that brought it to the threshold of the 1960s is now a well established historical fact. But both technology and a shifting balance of international power have posed serious problems in maintaining the future effectiveness of SAC. The U.S. monopoly in both atomic weapons and intercontinental delivery systems ended in the early 1950s. The advent of the intercontinental ballistic missile in the late 1950s provided the Soviet Union with a weapon of unparalleled advantage for devastating surprise attack. For the first time in postwar history an adversary has appeared on the international horizon with the capability and determination to challenge the effectiveness of SAC's striking forces.

Thus it is time for the American people to take a new look at SAC as it enters a period of revolutionary transition in weapons, tactics and deployment to surmount the challenge of the most formidable military power that has ever been marshaled against us.

To help provide an insight into this newly emerging pattern, AVIATION WEEK organized a special editorial task force which has spent three months in the field with SAC for an on-the-spot report of "SAC in transition" in a special insert beginning on page 101. To prepare this report AVIATION WEEK editors ranged from the bottom of the hardened missile silos at Vandenberg AFB, Calif., to the "jump" seat of a refueling boom operator at 30,000 ft. in a jet tanker and spent many hours in the underground control center at SAC Headquarters, Offutt AFB, Neb.

Areas of Debate

There are many areas of debate over future force levels, weapons mixes and operational procedures required by SAC to do its job in this period of transition. Perhaps the most immediate issue where the lines of disagreement are most clearly drawn is the airborne alert for the B-52 bomber fleet.

SAC has clearly indicated its requirement for moving toward a capability of keeping at least 25% of its B-52 fleet on continuous airborne alert configured to proceed immediately to targets in case of war. Joint Chiefs of Staff and Defense Department, with a strong scent of the Budget Bureau in the air, are contending that somewhere in the area of 12% is all that will really be required.

This is a decision that can mean the difference between effective deterrence of war or making the possibility of surprise ICBM attack attractive to a potential enemy. It is a decision that can mean the difference between winning a war if it comes or suffering the scorching disaster of defeat.

Clearly the American people must keep themselves informed on these debates for it is the force of public opinion that eventually makes the decisions on these issues.

"I do not think we will ever solve this problem," Gen. Thomas S. Power, SAC commander-in-chief told Congress, "until the American people understand it and are willing to do something about it. The military and the politicians are not going to solve this problem by themselves. It is the American people who are going to have to solve it."

How well the American people understand and solve this problem of supporting Strategic Air Command in its era of transition to an aerospace force will shape the peace of the world.

—Robert Hotz

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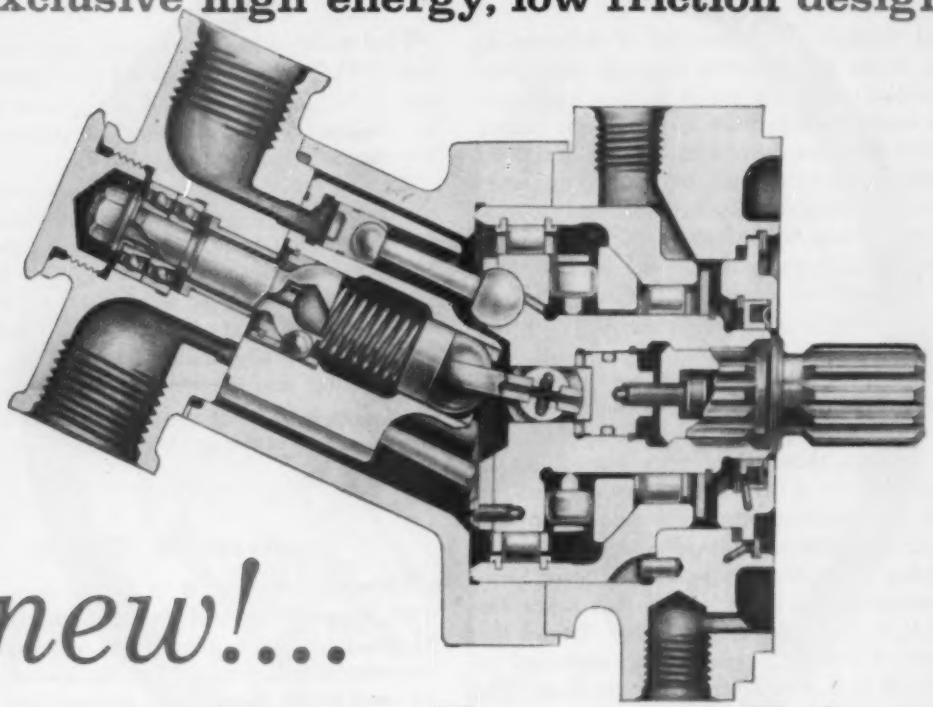

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Dr. Cledo Brunetti, president, Grand Central Rocket Co., Redlands, Calif.

Hugh C. Bream, president and general manager, Western Design, Goleta, Calif., a division of U. S. Industries, Inc.

Gustave A. Bleyle, vice president-engineering activities, Santa Monica (Calif.) office of Arthur D. Little, Inc.

Dr. Emanual R. Piore, vice president-research and engineering, International Business Machines Corp., New York, N. Y.

Melbourne A. Forrest, a vice president, Burns and Roe, Inc., New York, N. Y.

Dr. Lisle L. Wheeler, vice president-engineering, Sperry Gyroscope Co., Great Neck, N. Y., a division of Sperry Rand Corp.

Arthur L. Rossoff, vice president, Radio Receptor Co., Inc., Brooklyn, N. Y. Mr. Rossoff continues as technical director of Radio Receptor's Advanced Development Laboratory. Also: **Charles Hittner**, vice president and chief staff engineer, Engineering Products Division of Radio Receptor.

Lewis M. Duckor, vice president-engineering, Colvin Laboratories, Inc., East Orange, N. J.

C. J. Moore, vice president-marketing, Exide Industrial Division, The Electric Storage Battery Co., Philadelphia, Pa.

Lt. Col. Milton Frank will become Chief, Office of Information, Air Materiel Command, Wright-Patterson AFB, Ohio, succeeding **Col. Julian B. Cross** who will become Director of Information at Headquarters, Pacific Air Forces.

Honors and Elections

Harry J. Goett, director of the National Aeronautics and Space Administration's Goddard Space Flight Center, has been awarded an honorary Doctor of Engineering degree by New Mexico State University for his role as "international authority and recognized pioneer in solution of guidance and control problems of space vehicles and aircraft."

Frank W. Hulse, board chairman of Southern Airways Co., has been elected the first president of the National Aeronautical Services Assn. (NASA), Washington, D. C., recently formed by the merger of Aeronautical Training Society (ATS) and The Aircraft Service Assn. (TASA). **Henry I. McGee**, president of Dallas Airmotive, Inc., was elected vice president and will automatically succeed Mr. Hulse as NASA president next year; **Harry S. Baer, Jr.**, formerly with ATS, was elected secretary-treasurer. In addition to Messrs. Hulse and McGee, directors include: **E. Merritt Anderson** of Anderson Air Activities; **E. Fred Buehring** of Temco Aircraft Corp.; **George L. Carter** of Carter Aviation, Inc.; **Beverly E. Howard** of Hawthorne School of Aeronautics and Hawthorne Aviation; **Mrs. Isabel McKay** of Embry-Riddle Aeronautical Institute; **Ralph J. Osborn** of Lockheed Aircraft Service, Inc.; **Clarence E. Page** of Page Aircraft Maintenance, Inc.

(Continued on page 357)

INDUSTRY OBSERVER

► Atomic Energy Commission and USAF are testing both General Electric direct cycle and Pratt & Whitney indirect cycle nuclear aircraft engines at National Reactor Test Station in Idaho. Tests are expected to lead to a decision about next September to cancel one and go ahead with the other, leaving the loser with only a small state-of-the-art development contract.

► **Atlas Able VI is under consideration by National Aeronautics and Space Administration for launching as a Venus probe sometime next January.**

► USAF will soon announce the formation of an Institute of Energy Conversion Research at a Boston area university. It will specialize in basic and applied research in energy conversion techniques for application to satellite and space vehicles. Institute is intended as a means of attracting a small group of top scientists for work in this field.

► **Lockheed Agena B upper stage rocket, advanced version of the Agena now being used for Discoverer and Midas satellites, is tentatively scheduled for two trial firings next spring or summer in preparation for use in an experiment that would put a satellite into a very large eccentric orbit around the earth and moon.**

► Radio Corporation of America has developed new technique which enables thermionic energy converters to deliver higher efficiencies at lower temperatures. Company reportedly has obtained conversion efficiencies of 14% at temperatures of 1,100C. Work was sponsored by Advanced Research Projects Agency under direction of Air Force Cambridge Research Center.

► **Soviet scientists are showing interest in using dissociated gases of the upper atmosphere as energy sources for a supersonic recombination ramjet. Technical literature indicates that such engines will be produced late this year. Soviets have conducted an experiment in which 19.8 lb. of nitric acid was released at 62 mi. altitude, producing a cloud brighter than the moon by 10 min. after release. Similar experiments were first conducted by USAF in the U. S. several years ago and still are being done by USAF, NASA and others.**

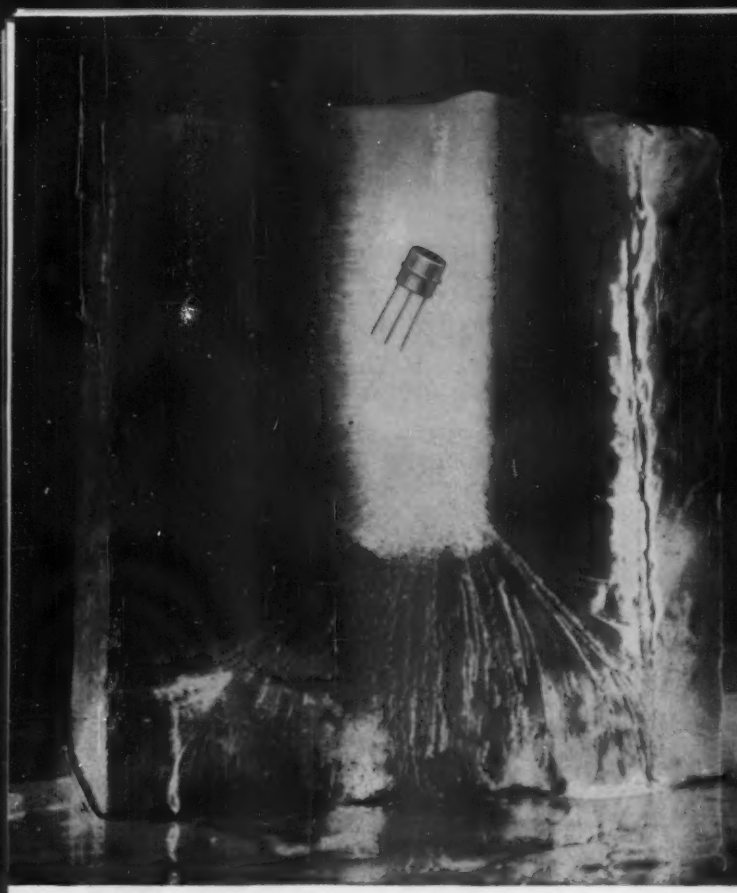
► Aircraft powered by turbofan engines will be more difficult targets for infrared guided missiles than aircraft using conventional turbojets, preliminary USAF and industry studies indicate. Relatively cold outer portion of the turbofan exhaust flow effectively shields the hot engine sections and high temperature part of the exhaust stream, which serve as homing points for missiles such as Sidewinder. Infrared target potential of the turbofan decreases as the fan bypass ratio increases.

► **Advanced Convair Terrier and Tartar surface-to-air missiles will be fitted with new type of homing guidance instead of the present beam-rider system. New system has been demonstrated successfully against drones at Edwards AFB.**

► First firing of a General Electric Mark 3 nose cone aboard a USAF-Martin Titan is expected in the near future. Although Mark 3 is scheduled for use on USAF-Convair Atlas rather than Titan, USAF requires that a number of ICBM components be interchangeable. Earlier availability of Mark 3 also means it could be used on Titan if necessary. Both the Titan and all Atlas squadrons eventually will carry Avco Mark 4 cones.

► **Wide range of wing loadings—from 5 psf. to 200 psf.—was studied in connection with the Dyna-Soar boost glide vehicle. Dyna-Soar figure will be less than 30 psf., compared with about 25 for the Lockheed U-2 and more than 100 for high-performance fighters.**

► Recent contest of air forces and anti-aircraft defense at Polish airfields included nine teams and more than 20 paratroopers. Aircraft were Ilyushin Il-2s, Il-5s and the Il-28 bomber. Contests included fighter combat, attack on bomber formations, fighter cover for bomber formations and delayed parachute jumps.



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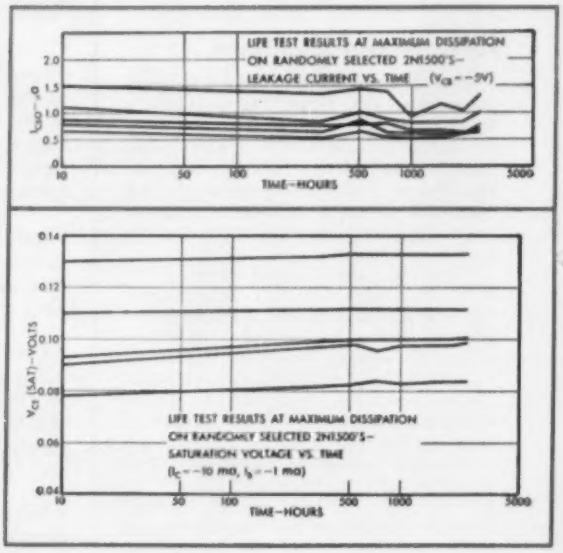

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Washington Roundup

Aerojet Complaint

Aerojet-General is asking National Aeronautics and Space Administration to reopen the 200,000-lb. thrust liquid hydrogen engine competition for Saturn upper stages. Disappointed at losing the competition to Rocketdyne, Aerojet argues that all large liquid propellant space engines are now concentrated in Rocketdyne's shops.

Rocketdyne's ability to stay within its low bid is challenged, and Aerojet claims technical superiority for its own original bid. Rocketdyne bid about $44 million for the development job, Aerojet's bid was $66 million and Pratt & Whitney's bid was over $120 million. Figures are not directly comparable because of differences in proposed test programs and other factors.

Aerojet proposes a competitive negotiation involving itself and Rocketdyne. Consideration would be given to incentive fee, cost sharing and possibly a fixed price contract.

Aerojet punctuated its argument last week with the first test firing of a hydrogen engine with all components arranged in the configuration proposed to NASA for the 200,000 lb. engine. Thrust was above 100,000 lb. and duration was about 10 sec. The same modified Titan thrust chamber, valves and hydrogen pump had been used for a number of earlier tests.

Liberalized NASA patent rules, which got through the House with little difficulty, are likely to run into trouble in the Senate. Senate Space Committee has indicated some opposition to provisions that don't require the government to take title to patents on work done under government contract. Opposition has also developed in other committees.

Senate also may cast a critical eye on the coordinating board favored by the House to coordinate NASA and military activities. House established this board when it approved the abolition of the present Civil-Military Liaison Committee and the National Space Council.

New Contract Policy

Defense Department and other agencies will have to favor labor surplus areas with their contracts after July 6. New policy is a revision of the defense manpower policy issued in 1950 to provide fast tax amortization for labor surplus areas.

Main immediate impact is expected to come in subcontracting. Location of plant facilities dictates placement of large prime contracts, but facility requirements for subcontracting are more flexible. Prime contractors are "encouraged" to place subcontracts in depressed areas.

Companies in labor surplus areas will get special treatment in bidding for contracts. A company will be given a chance to match the low bid for a negotiated contract if its bid doesn't exceed the low bid by more than 20% and if it is otherwise qualified. With advertised contracts, the job goes to the depressed area firm in case of a bidding tie.

Labor Department currently lists 20 major and 71 smaller areas of persistent high unemployment. These are localities with more than 6% of the labor force out of work three out of the past four years. Historically, Defense Department has spent 1 to 2% of its money in such areas.

American tourists are now barred from touring Soviet industrial plants and scientific institutes. This new Soviet cold war tactic is blamed on "similar action" by the U.S. government.

NASA's Office of Research Grants and Contracts has been shifted from the research branch to the business administration branch. The change essentially removes the grants' office from technical evaluation of proposed grants and research contracts. This function is moved into NASA technical offices.

Lloyd A. Wood, former head of the grants' office, is now adviser for advanced technology to Homer Joe Stewart, head of NASA's Office of Planning and Evaluation. New chief of the grants' office; T. L. K. Smull, Wood's former deputy.

House Republicans have produced a report on the U.S. strategic posture generally backing Administration policies. Survey recommends a priorities review board to make sure national resources are fully used. It also urges better coordination and timing of information issued by agencies concerned with national security. Responsibility for coordination is pinpointed in the White House.

Wrapup

House-Senate showdown on the 10% transportation tax is due this week. Senate Finance Committee voted to repeal it last week after the House earlier voted to extend it past the annual July 1 expiration date. . . . Army review of its entire research and development organization is reaching final stages where decisions will be made. . . . Senate and House Armed Services Committees will both issue reports on defense procurement policy and practices before the present session ends.

—Washington Staff

JCS Studies Targeting Strategy Revision

Specific Atlas, Titan, Polaris objectives involved; unified strategic weapon control is related problem.

By Edward H. Kolcum

Washington—Revision of national targeting strategy to incorporate specific objectives for Atlas, Polaris and Titan missiles is one of the most important issues now under consideration by Joint Chiefs of Staff. Study presently involves strategic weapons of Air Force and Navy, but delivery of Pershing to field troops next year will call for a strategic threat assignment for the Army as well.

Closely related to target strategy—Defense Department considers it part of the same problem—is integration of all strategic weapons control into a unified operational element. Decision on makeup of a joint strategic command will be made by Defense Secretary Thomas S. Gates, since the function of this command will involve changes in present operational policies, not in roles and missions.

Concept which appears least objectionable to the services is establishment of a management group directly under and reporting to JCS. Group probably would operate in a manner similar to the joint targeting staff, which advises JCS on assignment of forces and weapons to specific target areas on the basis of field reports.

A proposal to shift operational control of Polaris submarines to Strategic Air Command apparently has been scrapped. Still alive is an alternate recommendation that a Navy strategic command be organized with a command status equal to SAC. Both plans are unacceptable to the Navy, which historically has based its operational philosophy on unity of command vested in tactical fleet and task force commanders.

Management Proposal

Study of unified strategic management also includes a proposal that the new organization be set up along the lines of the U. S. air defense system, which maintains operational control over some elements of all three services. System probably would be more similar to North American Air Defense (NORAD) than to Continental Air Defense (CONAD), because inclusion of strategic forces of allies would make the command combined rather than just a joint U. S. command.

Targeting already is a combined function, with target coordination procedure now in effect with the United Kingdom. Air Force spokesman said U. S. would welcome British Vulcan and Victor bombers on SAC bases to augment alert forces. Although dispersal at U. S. bases of Royal Air Force strategic bombers is under study, problem of national sovereignty in any agreement on the method of ordering a nuclear strike is yet to be resolved.

If a unified strategic force is formed and accepted by all three services, it could be an indication that the services have come closer together on often-stated basic differences regarding the philosophy of the employment of nuclear weapons.

The Air Force contends that initial U. S. retaliation should be against forces of the enemy that can inflict further damage—missile installations and long-range bomber bases. To achieve this, Air Force believes the U. S. strategic attack plan must be computed in advance and computed precisely so that each weapon will have its target, bomb run patterns and penetrations can be orderly, and air crews will not be blinded from detonation or destroyed by blast overpressures.

The Army counters that the Air Force has programed for itself the nuclear capability to overkill targets by a factor of 10. Army position is that the outcome will depend on the total forces,

Pershing Launched on Preset Erratic Course

Army-Martin Pershing ballistic missile is launched from Pad 30A at Cape Canaveral Missile Test Annex, Fla., on June 9. The missile was preset to make erratic movements during its trajectory in a test of the flight control system.

both nuclear and conventional, which each side brings to bear against the other.

The Navy position is that operations in a nuclear war would not be concentrated against missile bases but directed against selected industrial areas. Navy maintains that such an operation would not require vast retaliatory forces at fixed installations. A minimum mobile deterrent force, 40 to 50 submarines each with 16 Polaris missiles, would suffice, making it unnecessary to engage the enemy's military forces, Navy says.

The Air Force argues that the outbreak of nuclear war will mark the end of significant usefulness of an industrial base, since it would be virtually impossible to assemble an end product from scattered production points, some certain to be hit by nuclear weapons. Contending that nuclear war will be brief, with employment possible only of forces and hardware immediately available, the Air Force points out that urban targets offer the prospect only of retaliation in kind and of resultant mutual annihilation. Even in a nuclear war, it is maintained, cities and people will tend to prevent what one strategist terms Armageddon—the final great conflict which could destroy the world. Continued existence of cities and people would serve as mutual deterrents to extensions of a limited nuclear war.

Defense spokesmen would not set a limit more precise than "this year" for a decision on unified strategic management.

It is unlikely, however, that any plan will result in complete agreement among the services on an "official" U.S. strategic philosophy.

Douglas Settles; Some Return at United

Production workers at United Aircraft's Connecticut plants—both union and non-union—last week began returning to their jobs, at first in small numbers that increased during the week. The return movement followed legal action by the company, two unions and the National Labor Relations Board.

United Auto Workers members who walked out of Douglas Aircraft plants at Long Beach, Calif., reached almost immediate settlement with the company, and a nine-day strike of the International Association of Machinists at Cape Canaveral, Fla., ended when a Convair contract offer involving missile bases was accepted. The offer does not apply to Convair plants at San Diego and Pomona where the IAM has been out for 11 days.

At San Francisco, negotiations were scheduled to resume between the IAM and Lockheed Missiles and Space Division for the first time since last Tuesday. Picket lines also are set up at division facilities at Van Nuys, Sunnyvale, Vandenberg AFB and Santa Cruz.

Douglas-UAW agreement provides for substantial improvements and additions to the company's insurance and pension programs and initiates a new program of extended layoff benefits based on length of service. Contract also calls for a seven cent increase in base wages in the second year of the contract and a current four cent cost of living increment becomes part of the employe's base wage.

Late last week, 6,727 production employes were back on the job at United's Pratt & Whitney, Sikorsky and Hamilton Standard divisions. Work force is 32.6% of United's 20,641 total roster. At Pratt & Whitney, for instance, 488 more employes reported for work than the day previously, United said.

United and the IAM and UAW, along with NLRB attorneys headed by Milo V. Price, reached an agreement on picketing restrictions similar to one granted United by a New York State court. Agreement bans mass picketing, violence and coercive language, and sets a 2½ ft. picket separation at the gates. Price said the new agreement, which goes to a U.S. court for ratification "specifically protects the right of a worker not to strike."

United will present data on unfair labor practice charges to the NLRB (involving violence) on June 28. However, the UAW has countered that United engaged in unfair labor practices by allowing photographers to take pictures of the pickets and has filed a formal charge.

One-day walkout—and a threat of continued once-a-week walkouts—occurred at Convair's San Diego and Astronautics Divisions when the Engineers and Architects Assn. left the job for picket lines. Association said it plans to walk off the job every Monday in a one-day strike for wage increases which, a union spokesman said, "will bring engineer's salaries to the level of building trades journeymen." At Chance Vought Aircraft, UAW workers also walked off their jobs for one day after rejecting a contract offer.

House Plan Calls For Accurate Cost Data

Washington—Legislation requiring defense contractors working on fixed price incentive contracts, used by Air Force and Navy in missile and aircraft procurement, to certify that their cost data is accurate has been unanimously approved by the House Armed Services Committee, headed by Rep. Carl Vinson (D.-Ga.).

The provision meets Rep. Vinson's complaint that "savings"—on which the contractor is awarded a profit—are largely due to excessive cost estimates when the incentive contract is negotiated. In its report, the committee observed that the legislation will assure that "the incentive profit over the normal profit will be the product of the contractor's action in performance rather than artificial pricing in negotiations for target price."

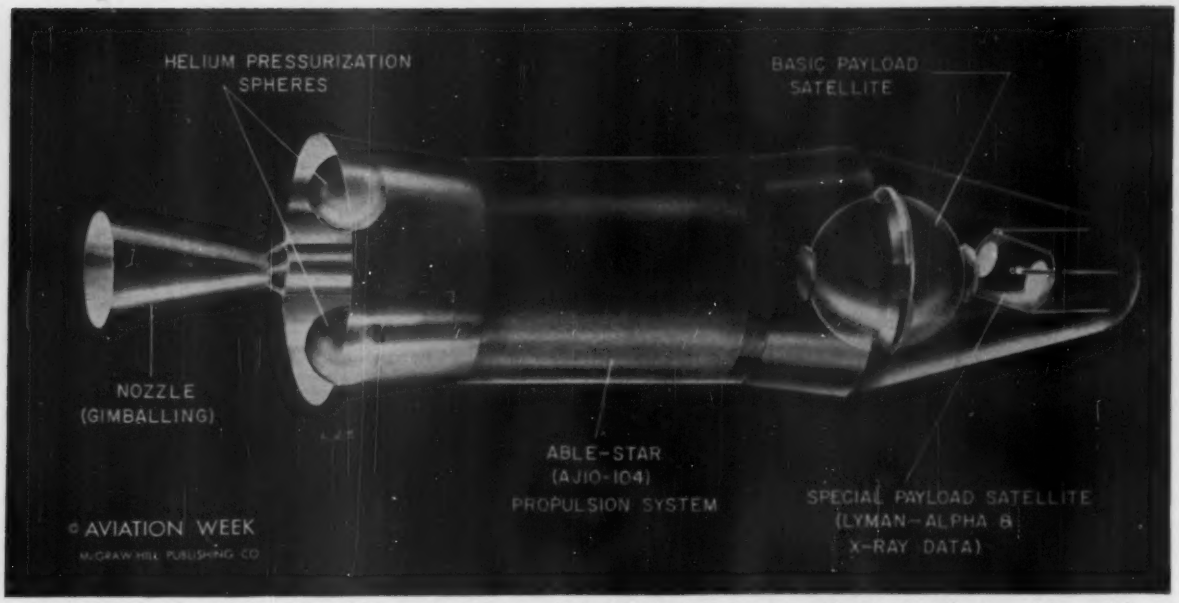
The committee reported that Defense Department "acquiesced" to the proposal, which reads: "No contract shall be negotiated . . . containing a profit formula that would allow the contractor increased fees or profits for cost reductions or target cost underruns, unless the contractor shall have certified that the cost data he submitted in negotiations for the fixing of the target cost or price was current, accurate, and complete; and that such contracts shall contain a provision that the target cost or price shall be adjusted to exclude any sums by which it may be found after audit that the target cost or price may have been increased as a result of any inaccurate, incomplete, or noncurrent data."

The Defense Department vigorously opposed previous legislation by Rep. Vinson which would have banned incentive payments unless the contractor could "clearly and completely demonstrate [they] are due to his skill, efficiency, or ingenuity. . . ." (AW June 6 p. 34).

The committee report maintained that the element of "risk" involved in incentive contracts does not appear to justify the payment of an "incentive profit" in addition to the normal profit. It said that of 171 Air Force incentive contracts totaling $6.3 billion, there was only one case in which the ceiling price was exceeded—and then by only $87,000. Penalties are invoked when a contract ceiling price is exceeded. Navy reported that of 47 incentive contracts for $2.5 billion, only one contractor paid $54,000.

Other provisions of the Vinson legislation are aimed at bringing "the rule of law" into defense procurement and re-emphasizing existing policy that (1) advertised competitive bid is the preferred method of contracting and that (2) there should be maximum competition in negotiated contracts.

The December, 1950, national emergency declared by the President, which Defense Department now uses as the authority for negotiating contracts rather than letting them by competitive bid, would be revoked in the Vinson bill.



SECOND-STAGE restartable Able Star liquid-propellant rocket vehicle includes basic navigation-aid payload satellite topped by special payload satellite to measure lyman-alpha and X-ray characteristics. The two satellites will orbit separately.

'Bonus' Payload Set for Transit 2A Orbit

Navigation-aid satellite will measure solar emissions; new trajectory to cross South American continent.

Washington—Two separate satellite payloads will be injected into a 500-naut mi. circular orbit in the Transit 2A navigation-aid system vehicle scheduled for launch between midnight and 2 a.m. June 21-22 from the Atlantic Missile Range over a new trajectory in the program.

Delayed from a projected launching on May 18, this Transit firing will be the third in a series of the Advanced Research Projects Agency-Navy-Applied Physics Laboratory program, and will go beyond the objectives of the predecessor Transit 1B (AW Mar. 28, p. 26, Apr. 18, p. 29) and include a "bonus" payload for return of solar-emission phenomena data in addition to the basic doppler-instrumented navigation-aid experiment.

Refinements in Transit 2A include:

• **Special payload incorporated** by Naval Research Laboratory for measurement of lyman-alpha and X-ray radiations. This is essentially a 20-in.-diameter sphere with relatively small volumes from two opposite surfaces slashed off, resulting in two flat sides. Energy for powering the special payload instrumentation will be four circular patterns of solar cells on the sphere's surface. Four whip-type antennas will extend out about 25 in. from the equatorial line of the special payload, which will be positioned directly on top of the basic navigation-aid payload.

When the Applied Physics Laboratory basic navigation-aid payload is separated from Transit's Able Star second stage boost vehicle and injected into orbit, the special payload also will be separated from the basic payload and orbit as a separate satellite.

General phenomena of lyman-alpha radiations are of considerable interest to space researchers. A spectral (emission) line, this short-wave-length light is in the far-ultraviolet range and is very energetic. Belief is that the lyman-alpha glow is produced in the exosphere as a result of excited hydrogen atoms. Since hydrogen is abundant in space, the presumption is that there is a considerable amount of lyman-alpha radiation, which could be very dangerous to space crews—causing extreme "sunburn" and affecting the eyes if there is no protection. Also, the radiations could cause emissions of electrons from a surface possibly causing damage to unprotected equipment.

X-rays, with shorter wave length and more energy than lyman-alpha radiations, are potentially more dangerous and possibly could penetrate space suits.

• **Basic navigation-aid payload** will be similar to the previous Transit satellite, but likely will be minus some of the instrumentation to retain the original 270-lb. weight and still accommodate above it, the special Naval Research Laboratory lyman-alpha and X-ray radiation payload.

• **Cosmic noise experiment**—important in the development or communication equipment—is included in the basic payload and is being performed for Canada's Defense Research Board.

Infrared Scanner

A Naval Ordnance Test Station-developed scanner will measure the earth's infrared intensity and transmit information, beginning after separation of the payload from the second stage booster, for a continuing period of one week only. Scanning will be done by a lead-sulphide cell in the infrared device, which will be rotating at approximately ¾ to 1 revolution per second around the maximum moment of inertia axis.

The NOTS infrared experiment is not related to the basic navigation experiment.

The 36-in. basic payload spherical shell will be a honeycomb sandwich consisting of ½-in. nylon-phenolic core between two face sheets of resin-impregnated Fiberglas. It will be stressed to withstand a pressure differential of 20 psi. between its internal volume and the outside-vacuum-condition of space.

Running between the upper and lower mating rings on this sphere is a Fiberglas tube for bracing the payload against launch forces.

Solar cells are located around the payload's equator. Configuration of this cell band may be changed somewhat from Transit 1B in that instead of a V-groove between upper and lower solar cell banks the center portion will resemble a truncated pyramid.

Outer surface of the satellite sphere will carry a wide-band, spiral, slot-type antenna, similar to that of Transit 1B.

Transit Trajectory

General path of the trajectory will take Transit 2A from Cape Canaveral in a southerly direction, cutting across South America, in contrast to the trajectory of Transit 1B, which was in a northeasterly direction over the North Atlantic.

Transit 2A will cross the South American coast in the general region where the adjacent northern areas of Colombia and Venezuela meet at the Caribbean Sea. Trajectory will continue across the western part of Brazil and pass over South America into the Atlantic in the general area between Buenos Aires and Montevideo.

Launch will be vertical, with a heading downrange of about 110 deg. Programmer in the Ballistic Missile Division-Space Technology Laboratories-Douglas unguided Thor booster will rotate the vehicle about a longitudinal axis, to give Transit 2A a heading of approximately 146 deg. at the beginning of the pitch program, when the programmer will put the vehicle into a gravity turn along the planned trajectory at the end of the roll maneuver.

LAUNCH
ABLE STAR FIRED (T+172 SEC.)
NOSE FAIRING JETTISONED (T+215 SEC.)
ABLE STAR COASTING BEGINS (T+448 SEC.)
ABLE STAR SECOND FIRING (T+1525 SEC.)
PAYLOAD SEPARATES (T+1555 SEC.)
AVIATION WEEK

TRANSIT 2A, third in a series of navigation satellite firings, will be launched in a southerly direction from Cape Canaveral, Fla., into a trajectory passing over South America. Intended orbit will be circular at an altitude of 500 naut. mi.

Transit 2A Aims

Basic navigation-aid experiment, under technical direction of Applied Physics Laboratory, will have these general objectives:

- **Establish feasibility of a satellite doppler navigation-aid system for ships and aircraft and lay foundation for development of ground network to complement the system.**
- **Geodetic analysis to determine, with very high accuracy, the figure of the earth. This study will enhance knowledge of orbit predictions and earth's gravitational field.**
- **Demonstrate relationship between ionosphere's refractive index and transmission frequency. Indications are that errors due to refraction effects can be minimized, perhaps eliminated. For this experimental analysis, basic satellite will transmit four c-w signals simultaneously.**

Included with the basic navigation-aid instrumentation, but unrelated to it, will be earth-infrared measurements, monitored by Naval Ordnance Test Station, and a cosmic noise experiment for Canada's Defense Research Board.

In addition to these objectives, Transit 2A will incorporate an auxiliary payload which will orbit separately to measure lyman-alpha and X-ray radiations.

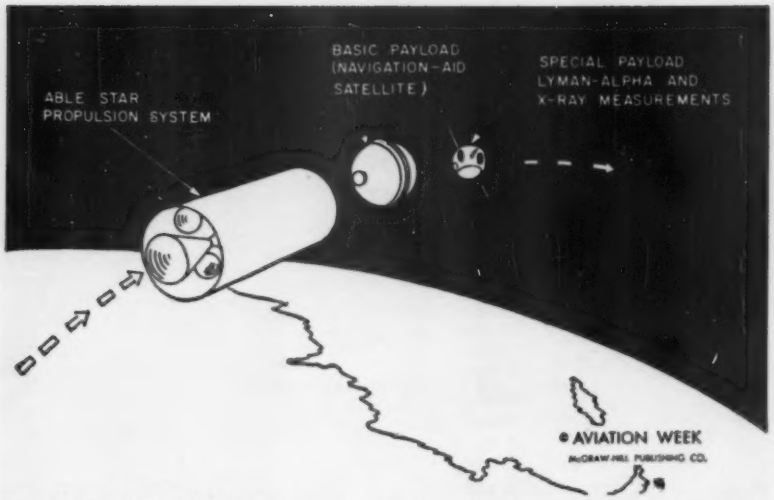
The Able Star AJ10-104 second-stage vehicle—developed under BMD cognizance with systems engineering and technical direction performed by Space Technology Laboratories and propulsion system built by Aerojet-General Corp.—will be directed by an STL automatic guidance system complemented by a Burroughs J-1 computer located at Cape Canaveral. Control of Able Star shutdown and restart functions will be by radio command to programmers in the vehicle. Able Star inhibited red fuming nitric acid and unsymmetrical dimethyl hydrazine mixture develops a specific impulse of about 275-280 lb.-sec., a thrust of about 7,870 lb., and a vehicle velocity of about 5,125 fps.

Trajectory highlights of Transit 2A include:

- **Liftoff (T) plus 149 sec.**—Thor booster cutoff is readied.
- **T plus 163 sec.**—Able Star ignition is readied.
- **T plus 166 sec.**—Able Star rocket burning is activated, explosive bolts are blown to separate second-stage Able Star from Thor, and about 5 sec. later, pitch program is started for Able Star.
- **T plus 215 sec.**—Nose fairing covering Applied Physics' basic payload and Naval Research special payload is jettisoned.
- **T plus 448 sec.**—Able Star rocket motor is cut off and vehicle's coast phase begins, continuing for approximately 18 min.
- **T plus 1,525 sec.**—Able Star rocket motor restarts.
- **T plus 1,539 sec.**—Able Star propulsion system cut off again, spin mechanism is alerted. At this cutoff time, Able Start vehicle will have reached the 500-naut. mi. orbit position.
- **T plus 1,555 sec.**—Payload section separates from Able Star vehicle. This involves separation of APL's basic payload from Able Star vehicle and separation of NRL special payload from the basic payload.

Basic payload will include four continuous-wave doppler transmitters and a frequency modulation/pulse modulation telemetry transmitter. Solar cells in conjunction with nickel cadmium batteries will constitute the power supply.

The four continuous-wave transmitters will operate continuously for approximately 45 days. Adequate data on the refractive index characteristics of the ionosphere should be collected in



SPACE VIEW of Transit 2A depicts separation and injection into approximate 500-naut.-mi. circular orbit. After burnout of Able Star vehicle (left) the basic payload (center) separates and is injected into orbit, followed shortly by separation of the special payload (right) from the basic payload. Basic payload is a navigation-aid satellite with a spiral slot antenna and a band of solar cells girdling it. Special payload is designed to study lyman-alpha and X-ray radiation, and has circular solar cell areas and whip antennas.

this period and the 54 mc. and 324 mc. transmitters probably will not be used after this time. The 162 mc. and the 216 mc. transmitters will be capable of on-off operation by command, and will operate for an indefinite period.

After the basic payload has been in orbit about 120 days, the feasibility of the doppler navigation system will be explored, using an APL mobile tracking station on the ground. Data, prepared by ground stations which will have analyzed the doppler shift will supply information to the mobile tracking van, which will use it in conjunction with orbit predictions to establish experimental results.

The special NRL payload will transmit information on lyman-alpha and X-ray radiations on its separate 108 mc. telemetry channel.

Canadian government's cosmic noise experiment data will be transmitted by modulating a telemetry channel. This will also be done for transmitting data on the thermal environment of the basic payload and other payload parameters. The Naval Ordnance infrared experiment, independent from the purpose of the basic APL payload, also will transmit information on its own channel.

Tracking stations will include six ground stations operated by Applied Physics Laboratory to receive continuous-wave transmissions from the satellite, encompassing stations at Air Force Missile Test Center at Cape Canaveral; Sao Paulo, Brazil; the mobile van, as well as APL's main station in Maryland to which data will be relayed.

Air Force's Space Navigation Center, manned by Air Force Ballistic Missile Division and Space Technology Laboratory personnel, will participate as well as a mobile STL telemetry van stationed in Chile to obtain information from second-stage Able Star telemetry and establish payload orbit-injection characteristics.

Naval Research Laboratory also will participate extensively, along with the three NOTS-monitored ground stations, and facilities of the Pacific Missile Range.

White Sands Missile Range tracking facilities also will be involved.

Interference Problem Attacked by Defense

Washington—Defense Department is launching a multi-pronged attack on the problem of radio frequency interference in the face of growing concern that mutual interference between large numbers of military radars and communications systems may prove more damaging than enemy electronic countermeasures.

The Defense Department program, outlined here during last week's National Symposium on Radio Frequency Interference by Henry Randall, Office of Director of Defense Research and Engineering, includes the following:

• **Electromagnetic Analysis Center** will be established in the near future to serve as a clearing house for technical data on the "electromagnetic signature" (radiation characteristics) and interference susceptibility of all military radar, radio, telemetry and radio navigation aids.

• **New military measurement** standard has been issued which specifies uniform procedures for measuring radio frequency spectrum characteristics of military electronic equipment to ensure that data can be used to predict mutual interference problems.

• **Minimum design standards** are now being developed by individual military services, with initial emphasis on radar equipments, which will establish allowable bandwidth limits, frequency stability, average radiation power levels for cross-modulation products, susceptibility limits for radar receivers to off-frequency signals and required antenna side-lobe suppression.

The new Electromagnetic Analysis Center, which will be operated by one of the military service laboratories or contracted out to industry, will establish a library of electromagnetic signatures for all military electronic equipments operating in the radio frequency spectrum. This will include data on the nature of radiation emitted by the equipment and the characteristic of other radiation which can interfere with its normal operation.

The Center also will maintain an environmental file which lists the numbers and types of military electronic equipments that will normally be used in a given geographic area and the duty cycle of each equipment, Randall said.

From all this data, the Center will be able to determine the effect of a proposed new piece or type of equipment and its possible interference with other equipment. Much of the analysis will be performed by digital computers.

The new Military Standard on Measurement of Radio Frequency Spectrum Characteristics, prepared by representatives of the three services, is expected to become a joint-service requirement in future development and production contracts for military electronics equipment, according to Randall. Defense Department may award contracts for making such measurements of existing equipments now in the inventory.

Space Power System

Dayton—Team headed by AiResearch Division of The Garrett Corp. has won Air Force competition to develop 300 kw. nuclear-reactor turbine-generator powerplant for use in space vehicles. This will be the largest such system under development. Design objective is to achieve reliable operational lifetime of one year. System is to have growth potential to reach 1,000 kw.

AiResearch associates include Aerojet-General, which will provide nuclear reactor, and Westinghouse Electric which will supply electrical generator and accessories. Initial contract will be for approximately $750,000, with additional funding in Fiscal 1961. Program is under cognizance of Wright Air Development Division's Flight Vehicle Power Branch.

National Intelligence Principles Outlined

By Katherine Johnsen

Washington—Senate subcommittee on national policy machinery last week issued a declaration of "cardinal principles" to guide a free society's use of intelligence activities because "recent events have focused public attention upon this matter."

The subcommittee, headed by Sen. Henry Jackson (D.-Wash.), said the principles were drawn from hearings it has held over the past year and will guide its future studies of intelligence and national security planning.

The principles include:

- **"Intelligence is as important** as armed strength. In this age of push-button weapons, intelligence is more than ever our first line of defense."
- **Since intelligence operations** are instruments of national policy, "they must be subject to effective and continuing higher review and coordination. This includes a weighing of gains against risks."
- **Intelligence is "a job for professionals"** and officials who depend upon it "must be professional in handling the problems which it raises." Intelligence organization should be "tight, centralized, responsive, and to the greatest possible extent anonymous.
- **"The conduct of diplomacy** must be insulated from sensitive intelligence operations. Intelligence is a source of information for diplomacy—not a part of it."
- **Public revelation of sensitive** intelligence "is never a harmless act. It both jeopardizes the normal conduct of foreign relations and compromises the sources of vital intelligence. If public statements have to be made at all, they must be made only in response to overriding national interest and on the responsibility and under the control from the outset of one high authority.
- **"The golden word of intelligence** is silence. More can be lost by saying too much, too soon, than by saying too little, too slowly."

The subcommittee commented that recent events—obviously the U-2 incident—have "attested to the wisdom" of these principles.

Earlier in the week, Secretary of State Christian Herter and Defense Secretary Thomas S. Gates defended present organization of the nation's top policy-making machinery in hearings before Jackson's subcommittee.

Asked by Sen. Jacob Javits (R.-N.Y.) whether "recent events"—presumably the handling of the U-2 incident—had demonstrated national policy-making procedures as satisfactory, Gates said that they showed that "the leadership is adequate, the coordination is adequate, and that the people have been informed as well as they can be."

Herter told the subcommittee that "there actually is . . . close operational relationship" between State, Defense and Central Intelligence Agency.

Gates emphasized that the National Security Council "is functioning effectively and efficiently" as the top advisory body to the President, and that "the President himself makes the decisions." Gates protested "public comments suggesting that the council may be too large, suggesting that meetings are conducted in a so-called 'mass' atmosphere, suggesting that too much of the essential debate may be taking place at lower staff levels, suggesting that top level discussions become smothered in papers, and suggesting that the council is somehow insulating the President from so-called 'hard facts' and 'hard decisions.' Frankly, I am at a loss to know the basis for such observations. . . ."

Gates concurred with Jackson that a Senate resolution should be passed stating that Defense secretaries should serve for a minimum of four years and that they should be barred from direct political activity.

Herter reported that State Department is developing liaison with the office of Dr. Herbert York, Defense director of research and engineering, so that the international psychological implications—as well as the strictly military implications—may be given weight in decisions as to which weapon systems to push.

Discussing the law requiring the Defense appointees to dispose of their stock, Jackson said the statute is outmoded and discourages high calibre individuals from accepting posts. Jackson commented that "if a man is a crook, the simple act of disposing of some stock is not going to stop him from being a crook."

Gates said that appointees with only a small percentage of ownership in a firm with defense contracts should be required to file their holdings with congressional committees, but permitted to keep their stock.

Saturn Booster Fired for 122 sec.

Huntsville, Ala.—Saturn booster underwent its longest static firing to date here last week. Firing involved all eight engines and lasted for 122 sec.

With each engine producing 165,000 lb. thrust, the booster developed a total thrust of 1.3 million lb. In later firings the engines will be operated at their full capability of 188,000 lb. thrust to produce the design over-all booster thrust of 1.5 million lb.

Last week's static firing was the sixth in which all eight of the booster engines were operated. Durations of these earlier full configuration firings were, in order, 8, 25, 35, 75, and 110 sec. First static firing of the Saturn involved only two engines. The second involved four engines.

The latest firing was carried out in conjunction with the dedication of the IBM 7090 Data Processing System Computation Laboratory of what will become on July 1 the National Aeronautics and Space Administration's George C. Marshall Space Flight Center located here at Redstone Arsenal.

The new 7090 computer system, which the space center is renting from the International Business Machines Corp. at $64,000 a month, is reported to be the most powerful data processing system yet delivered in this country. It will be used for research, design, development and flight simulation work in the Project Saturn program.

First actual flight test of the Saturn, according to Space Center Director Wernher von Braun, is scheduled for next summer. This will be a suborbital shot of the Saturn C-1 configuration (AW May 9, p. 52) in which only the booster will be live and stages two and three will be dummies.

Three more Saturn test flights are scheduled for 1962. Of these the first two will be similar C-1 configurations in which the booster unit is the only live stage.

The third will be fired in late 1962 using live first and second stages and a dummy third stage. Five more Saturn C-1 test vehicles will be flown in 1963, von Braun said. The first two of these, test vehicles 5 and 6, will again be configurations in which the third stage will be inactive. Flights of vehicles 7, 8 and 9 will be flown with all three stages live. Payloads for flight vehicles 7, 8 and 9 which will be orbital shots, will be worked out in conjunction with NASA scientists at the Goddard Space Flight Center for application to the man-in-space program.

Flight of vehicle 10, which will be the last of the Saturn test vehicles, is scheduled for the spring of 1964. This will be followed later that year by flight vehicle 11 which will be the first operational Saturn C-1 vehicle.

York Must Approve New Projects If Cost or Technical Impact Is High

Washington—Dr. Herbert York, Defense director of research and engineering, reported to Senate Appropriations Military Subcommittee that he now must approve of all new projects involving over $2 million for one year or over $10 million for a three year period.

"This procedure is designed to bring into the open for top level decisions any major shifts in emphasis as well as the initiation of costly programs which would have a profound effect on program planning and budgeting in the near future," he observed.

York said that he relies on intelligence from both Central Intelligence Agency and the military intelligence services for guidance in making decisions.

"There are occasional disagreements between them in details, but there are no disagreements between them in general terms that make any real difference with regard to what our development programs are like," he commented. "I deal with both of them simply because I know people in both of them and it depends on what question has arisen as to whom I think I might best ask, not because of disagreement."

York said he is "in very close touch with the status of the Soviet development programs."

Other highlights of York's testimony, presented in executive session late in March but released this month, were:

• **"Major objective"** of Project Defender is to find means for interception of an intercontinental ballistic missile during any phase of its flight, including the launch phase.

York reported that Defense has "several study programs" and "some related research programs" under way with the objective of destroying ICBMs at launch points. He said that "there are some interesting ideas" but that none of them "at the present time have been judged good enough or firm enough to enable us to initiate a large-scale development program related to them."

• **York reported** that to defend only a part of the U. S. with Nike Zeus antimissile missiles will cost approximately $15 billion. He said that it would be "utterly impossible" to defend the entire territory of 3 million sq. mi. of the U. S. with this point defense system. York reported that it will take two years to complete tests on the Nike Zeus system, at which time a decision can be made on whether to move into production. He noted that other developments in the interim may influence the decision—particularly developments in launch, instead of terminal, interception.

• **Although the Midas** missile warning system is "being pressed," York said that it cannot be available until "the latter half of this decade." He noted that "predominant military opinion" is that early warning is the highest priority item of the air defense programs. York pointed out that there still are "large factors of uncertainty" in the Midas project. He said it is still unknown as to how many satellites would have to be launched each year for an effective warning system.

• **Approximately 72%** of Defense Department research, development, test and evaluation work is accomplished by contract with industrial organizations, 7% by educational and other nonprofit institutions, and 21% by federal government installations, according to York.

NASA Life Sciences Activity Is Questioned

Washington—Members of the House Committee on Science and Astronautics last week questioned the wisdom of having an office of life sciences in the National Aeronautics and Space Administration instead of using Defense Department capability in this field.

Reps. Emilio Daddario (D.-Conn.) and Walter Moeller (D.-Ohio) directed critical questions along this line at Dr. Clark T. Randt, director of NASA's life science programs, when he appeared to review organization of the program.

Both Daddario and Moeller said they could not see why NASA wants to create a separate life science center when its program could be carried out in cooperation with the military services and other existing research institutions. Rep. Daddario said he could quote many witnesses who appeared before the committee earlier and who contend that the services have the capabilities to carry out current and future experiments in life sciences which would lead to manned space flight.

Dr. Randt explained that NASA intends to cooperate with the services and other organizations which would do most of the actual experimental work, but that NASA needed an in-house capability to provide the leadership and direction for a national program. Its authority to set up such an organization stems from the National Space Act of 1958 which directs NASA to conduct civilian aspects of space exploration, he said.

Space Drug Developed

Washington—A drug to reduce the biological effects of ionizing radiation is being developed at the Walter Reed Army Institute of Research, according to Lt. Col. James Hartgering of the Army's Life Sciences Division.

Hartgering told the House Space Committee last week that the drug is being developed for use of troops in case of nuclear war to reduce casualties, but he said it would be equally effective for space use in traversing the Van Allen radiation belt.

Hartgering told the committee that two years ago the drug was given to a dog which was then exposed to radiation that would ordinarily have killed it within a week. The dog is still in good health today. Since the drug has a toxic effect on humans, he said, current research is directed toward changing the compound to one which humans can take without ill effects.

Brig. Gen. Don Flickinger, assistant for bio-astronautics, Air Research and Development Command headquarters, told the committee that the Air Force biomedical capability today represents the "largest single competency to support manned aerospace flight in the Western world." He said 1,200 Air Force life scientists are actively engaged in studying the problems of aerospace and that Air Force officers have "dominated the literature" throughout the history of aviation medicine.

Army and Navy witnesses also told the committee that while their work was not necessarily connected directly with support of space life sciences, the knowledge gained from their programs often have a direct bearing on the space program.

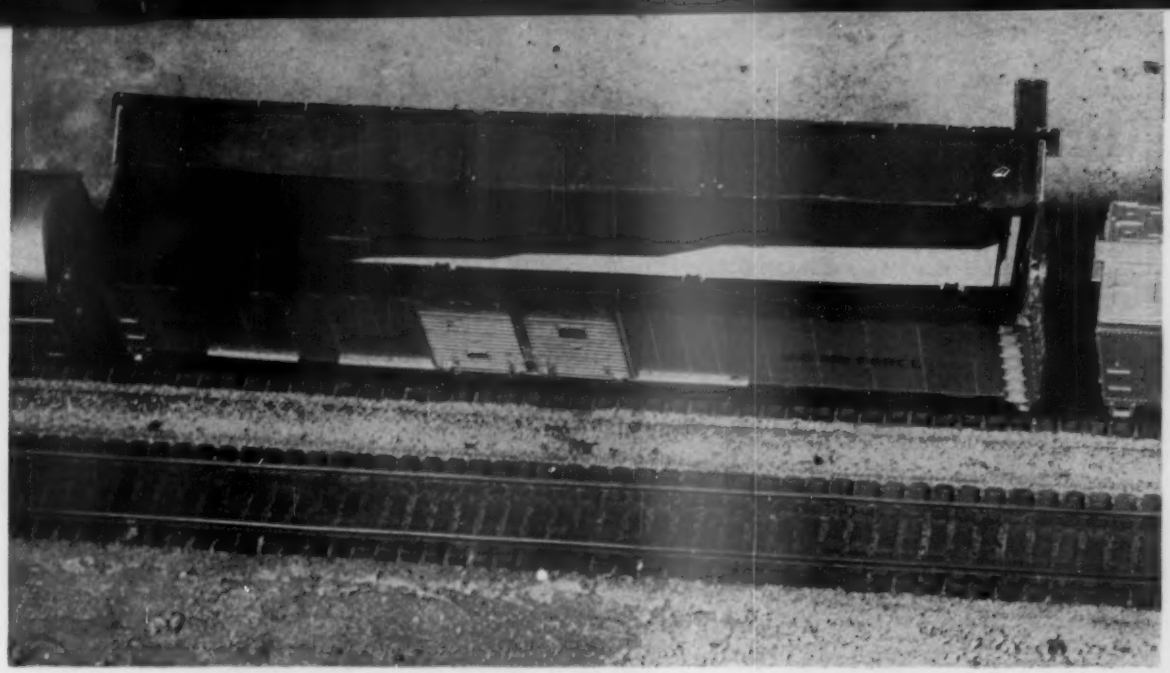
Objects Left Transit In Dual-Payload Test

Washington—Objects orbiting in the general vicinity of Transit 1B and Midas II satellites have been identified as parts of payloads programed to leave the main instrument containers.

Transit 1B contained a clamp-strap assembly with spring bolt which was actuated in a successful test of the separation of two satellites launched as a single payload. Lightweight metal disk simulated the second payload and is orbiting the earth with a period of 93.8 min.

The main satellite has a period of 95.7 min.

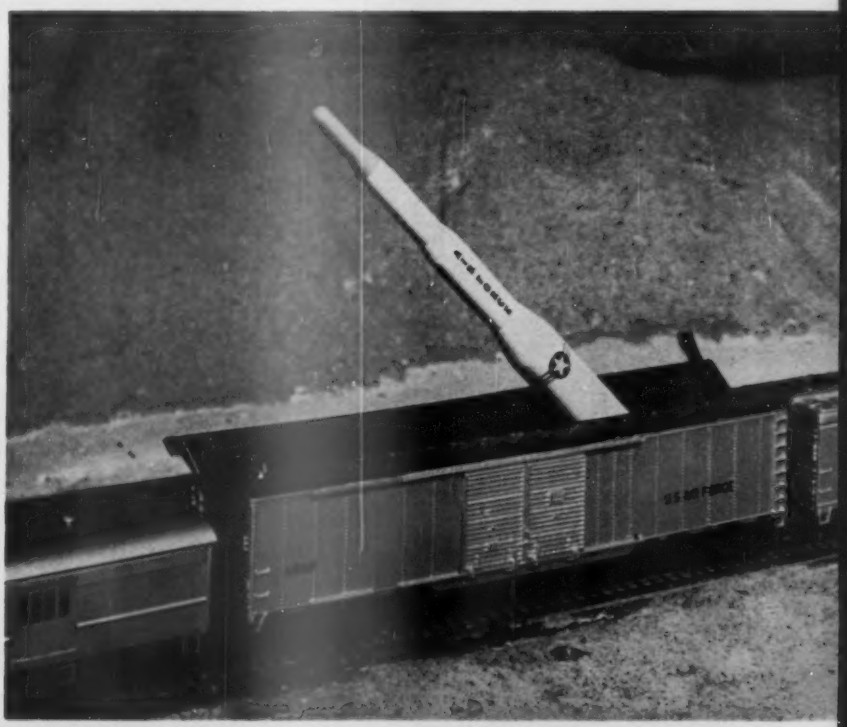
Glass fiber and metal fairing which protected Midas II payload was jettisoned after orbit was achieved and is orbiting close to the instrument package. Both have orbital periods of 94.4 min.

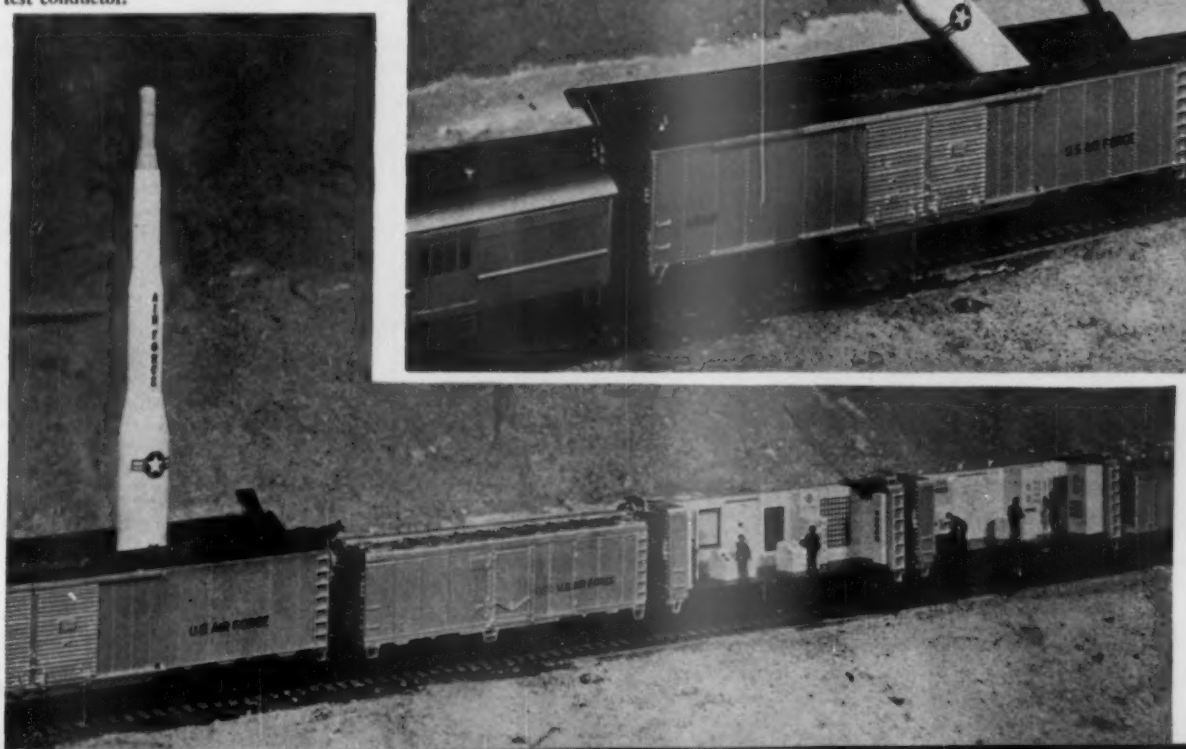


Model of Minuteman ICBM missile car shows unit with roof open; configuration is early concept and does not depict operational car.

Minuteman ICBM Train Concept Displayed in Model

First test run of Minuteman intercontinental ballistic missile train is scheduled to leave Hill AFB, Utah, today (June 20) over trackage of Union Pacific, Western Pacific and Denver & Rio Grande railroads. Model at right shows the solid propellant ICBM in partially raised position, following alert from the command car (see p. 168) and fully raised (below). First test train will consist of 14 cars, all owned by Department of Defense; more than 20 railroads eventually will be involved in the tests. Strategic Air Command will be in operational control and USAF's Ballistic Missile Division will be test conductor.





Mutual Security Program Cut Sharply

By Ford Eastman

Washington—House Appropriations Committee ignored the strong objections of President Eisenhower last week and slashed $790.5 million from the Fiscal 1961 mutual security program budget requests.

The committee approved $3,384,500,000 for the program, a sharp cut from the $4,175,000,000 Administration request. House group recommended that the $2 billion requested for military assistance be cut to $1.6 billion and that $724 million asked for defense support programs be reduced to $600 million.

House Republican Policy Committee worked to gather support for the Administration requests as the appropriation bill headed for debate on the House floor late last week. Support came from a group of liberal Democrats for an effort to restore $250 million of the amount cut by the committee.

Before leaving on his trip to the Far East, President Eisenhower had asked Republican congressional leaders for cooperation in restoring mutual aid budget cuts in the interest of "our own security and for the common defense of the free world."

Opposition to the committee cuts came from within the committee itself in a minority report filed by Reps. John Tabor (R.-N.Y.), Gerald R. Ford, Jr., (R.-Mich.), John J. Rhodes (R.-Ariz.) and Silvio O. Conte (R.-Mass.), all members of the appropriations subcommittee which handled the mutual security bill. Minority report said:

"These cuts are not justified by the testimony heard by our subcommittee, particularly in view of the most urgent requests and warnings by the President of the United States, the Secretary of State and the Secretary of Defense.

"These cuts will compel reductions in needed military assistance to our allies at the precise moment when Khrushchev and the Soviet Defense Minister Malinovsky are threatening them with rocket attacks. They will force serious reductions in economic help to struggling nations at the very moment when the Communist bloc is accelerating its efforts at economic penetration and control of these hundreds of millions of people who constitute the balance of power in the world. They will undermine the security of the United States at one of the most critical times in the history of our country. . . . It is our belief that national interest requires that substantial increases be made for MAP and defense support."

Before the budget requests were cut, the House Appropriations Subcommittee on Foreign Operations, headed by Rep. Otto E. Passman (D.-La.), was told the $2 billion requested by the Administration for military assistance would be split this way:

- **About $520 million** would be absorbed by relatively fixed costs such as training, mutual weapons development, intrastructure and supply operations.
- **$615 million** was allotted for force maintenance—provision of spare parts, training ammunition, attrition replacements and other maintenance of allied forces, primarily in the less developed countries.
- **Remaining $865 million** was planned to improve the retaliatory and deterrent capability of North Atlantic Treaty Organization nations and other key allies. More than half of this amount was for missiles, electronics and advanced aircraft.

Committee minority report pointed out that, since little can be shaved off the category of fixed charges and since it is "both difficult and dangerous" to apply cuts to the force maintenance programs, there remains only the force improvement area to absorb the reductions. This is an area in which "money is most needed," the group said, to buy weapons, equipment and other materiel vital to strengthening the forces of allies and to the effectiveness of the NATO alliance.

Minority report said that "this damage to the strength of our common defense . . . is intensified by the fact that last year the major impact of the $300 million cut in the budget request had to be absorbed in this vital area of force improvement through postponements and deferments of programs."

The group pointed out that the pipeline backlog which once made it possible to continue deliveries despite reductions in budget requests has dropped from a high of about $8.5 billion seven years ago to less than $2.2 billion at the end of the current fiscal year. Witnesses have told the committee that because of the long lead time involved between appropriations and deliveries and the necessity of carrying forward an unspent balance of $2.5 billion at the end of the preceding fiscal year, cuts in new obligating authority mean curtailment of expenditures.

Directing its attention specifically to defense support, the minority group said the cuts proposed are a "severe and dangerous" reduction in an essential program and urged restoration of the deleted funds.

Defense support provides economic aid to 12 nations to enable their economies to support military forces beyond their ordinary economic capability.

"The Communist bloc can be relied upon to probe and exploit any suspected weakness in this strategic perimeter" of 12 nations, the minority said. "While their efforts and skill at economic penetration have increased, there is no evidence that the military threat has in any way diminished. The hearings developed considerable evidence to the contrary:

- **"Along with the implied desire** to maintain or heighten tensions which are visible in Soviet disruption of the summit conference, much evidence was presented that they are intensifying their campaign to neutralize overseas bases—using all of their standard threats plus new and violent threats of rocket attacks.
- **"In the Far East,** armistice violations by North Korea, sporadic cannonades

Aerospace Board Sets First Meeting

Washington—Board of trustees of the new nonprofit Aerospace Corp. will hold its first meeting Friday or Saturday in the Los Angeles area to create the nucleus of the corporation, establish salary levels and patent policies and try to project research programs for future work.

Aerospace was incorporated June 3 to replace Space Technology Laboratories, Inc., as a technical arm for USAF's Ballistic Missile Division (AW June 13, p. 34). Roswell L. Gilpatric, New York attorney and former USAF undersecretary, has been named board chairman, and the firm's contract with USAF already has been signed. No president had been selected late last week. Secretary and general counsel is Najeeb E. Halaby, former Defense official and now a Beverly Hills, Calif., attorney.

Board members include Dr. Jerome Wiesner of Massachusetts Institute of Technology; Dr. Charles C. Lauritsen, professor of physics at California Institute of Technology; Dr. Clifford C. Furnas, former assistant secretary of defense for research and development; Roger Lewis, executive vice president of Pan American World Airways, Inc., and former USAF assistant secretary for materiel; Trevor Gardner, former USAF assistant secretary for research and development; two retired USAF generals, Earl Partridge and James McCormack; and several others.

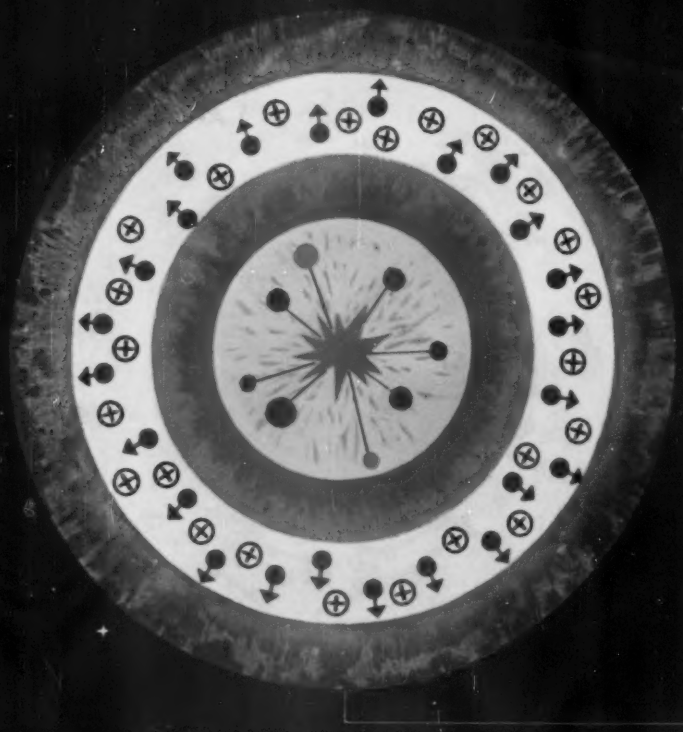
To keep the lonely vigil... *Martin PM-1 air-portable nuclear reactor, to supply electricity and heat at remote Air Force stations, is now being developed and produced for the AEC.*

MARTIN

ANOTHER ASPECT

OF THE

MARQUARDT MISSION



PLASMA THERMIONICS FOR SPACE POWER

The most ideal electric power sources yet devised for the operation of space vehicles are the nuclear and solar heated plasma thermionic systems which are in work in ASTRO, Marquardt's division for research into the space age.

Planned to replace the heavier, and more complex turbo-electric systems, ASTRO's designs employ the plasma diode thermionic converter to transform nuclear or solar energy into electric power without the use of moving parts.

The conversion is extremely simple. Nuclear or solar energy heats a refractory metal plate (a cathode) to a temperature far beyond the melting point of steel. This causes electrons to be boiled off and collected by a cooler plate—thereby creating electrical energy. Cesium plasma is contained between the two plates which form the cell. The positive cesium ions help the electrons along during their movement from the heated to the cooled elements of the cell, thus, increasing the amount of current that can be made to flow.

ASTRO's plasma thermionic power studies typify but one aspect of The Marquardt Mission.

Creative engineers and scientists are needed.

ASTRO DIVISION

THE Marquardt CORPORATION

CORPORATE OFFICES: VAN NUYS, CALIFORNIA

◆ ASTRO ◆ COOPER DEVELOPMENT DIVISION ◆ OGDEN DIVISION ◆ POMONA DIVISION ◆ POWER SYSTEMS GROUP

in the Taiwan Straits, and subversion in and infiltration into South Vietnam and Laos, are overshadowed by the ominous fact of Red Chinese strength, and willingness to use force to expand along her southern border."

Supporters of reduced foreign aid also referred to testimony before the subcommittee to point out examples of "extravagance and waste" in the administration of the program.

Rep. H. R. Gross (R.-Iowa) said if the President would read the printed hearings he would note that extravagance and waste justifies more than the $800 million cut in the "foreign handout program" and he said he hoped that a total of more than $1 billion would be cut.

Rep. Wayne L. Hays (D.-Ohio) said he has heard for years that cuts in appropriations would cripple the program, yet the House has cut the program each year, "and it has continued to go on with a good deal of waste."

Another witness, Gen. Williston B. Palmer, director of military assistance, furnished the committee with the amounts programed for operational missiles under MAP from Fiscal 1956 through Fiscal 1960, plus funds planned for Fiscal 1961.

They are:

- **Corporal.** Allotted for Europe but undistributed: $20,875,000. No money programed for Fiscal 1961.
- **Nike Ajax and Hercules,** for NATO and Far East, undistributed: $159,740,000.

An additional $53,013,000 is programed for Fiscal 1961.

- **Honest John,** for NATO: $32,077,000 through Fiscal 1960, plus another $8,533,000 for Fiscal 1961.
- **Sidewinder,** for Europe, Near East, South Asia and Far East: $15,883,000 to Fiscal 1960, plus another $5,848,000 for 1961.
- **Jupiter and Thor IRBMs** for NATO: $282,068,000, plus another $31,900,000 for 1961.

Wayward Balloon

Washington—The Navy last week planned to mount a search effort to locate a 500-ft. plastic balloon launched June 5 which drifted out of radar contact eight days later when it was 700 mi. west of San Diego. Late last week, it was not known whether the balloon was in the air or down at sea.

The gondola contains 800 lb. of emulsion to record cosmic ray phenomena (AW June 13, p. 37). The instrument package was to have separated from the balloon after a two-day flight of 850 mi. The separation device apparently froze, preventing scheduled recovery. Navy fighters then unsuccessfully attempted to shoot the balloon down.

- **Tartar,** for Europe and Far East: $8,700,000, plus $14,871,000 for 1961.
- **Terrier,** for Europe: $2,553,000, plus $31,016,000 for 1961.
- **SS10-11,** for Near East, South Asia and Far East: $3,600,000.
- **Target drones,** for NATO and Far East: $2,388,000 programed for 1961 only.
- **Lacrosse,** for Europe: $10,000 for 1961 only.
- **Mace,** for Europe: $18,526,000, plus $31,415,000 for 1961.
- **Sergeant,** for Europe: $10,010,000 for 1961 only.
- **Hawk,** for Far East: $16,400,000 for 1961 only.
- **Davy Crockett,** for NATO: $1,327,000 for 1961 only.
- **Missile spares** and components, for Europe, Near East, South Asia and Far East: $26,017,000, plus $3,780,000 for 1961.

News Digest

Compound semiconductors capable of operating at high temperatures and frequencies are gaining emphasis in military and space programs, it was reported at the Solid State Device Research Conference last week in Pittsburgh, Pa.

Boeing Airplane Co. last week was awarded a $2,082,215 fixed fee contract to build Navy's first operational hydrofoil vessel, a 115-ft. long, 110-ton aluminum anti-submarine warfare patrol craft. Designated PCH, it will be built by Boeing's Aero-Space Division in leased facilities at Tacoma, Wash.

Morane-Saulnier has 60 firm orders for its all-metal MS-880 Rallye sport plane (see p. 272). Company will set up tooling and assembly line for initial batch of 250 planes.

USAF-Convair Atlas 54-D flew 4,300 naut. mi. last week in the first flight to be guided by the Arma all-inertial guidance system. Arma system was carried on a checkout flight last March but did not control the missile.

Brig. Gen. John G. Shinkle will replace retiring Maj. Gen. Waldo E. Laidlaw as commander of White Sands Missile Range late this month.

Extra $20 million in research and development funds was added to National Aeronautics and Space Administration's Fiscal 1961 budget request last week by the Senate Independent Offices Appropriations Subcommittee. This will bring the total budget to $935 million, with $565 million of it for research and development, if the full committee and the Senate approve the figures, as expected. NASA has legislative authorization for an additional $35 million in research money and $5 million for construction and equipment funds, but the Administration so far has refused to let NASA ask for more than the original $915 million.

Rear Adm. William D. Irvin has been named first Chief of the Defense Communications Agency (DCA), which was established recently to provide centralized control of all long-haul communications for the three services. Adm. Irvin, former Commander of the Atlantic Fleet Operational Test and Evaluation Force, will be directly responsible to Secretary of Defense through the Joint Chiefs of Staff.

National Aeronautics Assn. has broadened the scope of the Collier Trophy so the trophy committee can consider designers or builders of missiles and space vehicles for the award.

Nortronics contracts for three of 10 adapters to be used in conjunction with Bendix AN/GJQ-9 universal test set for inertial guidance subsystem of GAM 87A Skybolt air-launched ballistic missile are expected to be awarded June 27. The three adapters will be for inertial platform control, astro tracker control and astronertial instrument. Bidders include Packard Bell, Hughes, Bendix, RCA, ITT Federal, Motorola, Curtiss-Wright, Sperry Gyroscope, Stromberg Carlson and Hycon Mfg. Each adapter will cost $150,000-$200,000.

General Electric Co. has proposed a new MF239C turbofan engine rated at 21,000 lb. thrust and intended primarily for use on the next generation of Military Air Transport Service transports.

Advent Organization

Washington—Bidders' briefing conference for Project Advent communications satellite was held last week by Army Signal Corps despite the fact that Defense Department has not yet approved proposed program organization (AW June 13, p. 33). Defense is withholding approval until responsibilities of the three agencies involved, Army Signal Corps, Air Force Ballistic Missile Division and National Aeronautics and Space Administration, are clearly defined. Signal Corps will be responsible for vehicle-borne communications, BMD for the satellite itself and its launching, while Centaur launch vehicle will be developed by NASA. When communications satellites become operational, Army is expected to be named the responsible agency.

ATA Criticizes FAA Data Link Program

Airlines question whether RCA system meets needs, outline basic requirements for an operational system.

By Philip J. Klass

Washington—Air Transport Assn. formally advised the Federal Aviation Agency last week that it questions whether the automatic ground-air communications systems (AGACS) developed by Radio Corporation of America and now under FAA test meets the basic operational requirements of airspace users, particularly the airlines.

The association's statement was precipitated by FAA plans to purchase 20 of the RCA units for operational evaluation, an action which ATA fears would irrevocably commit the agency to the RCA data link system.

When FAA originally selected RCA to develop AGACS in the face of many competing techniques and systems (AW July 28, 1958, p. 70), its announced purpose was to obtain a data link which it could test to obtain answers to operational requirement questions which had long been debated. FAA emphasized at the time that in selecting the RCA AGACS for experimentation, it was not committing itself to the system for subsequent nationwide implementation.

The airlines originally supported the FAA program with RCA but went on record a year ago in favor of FAA "supporting evaluation of worthwhile alternative techniques."

Within FAA there have been those who felt that the agency should simultaneously investigate other data link systems. About a year ago, FAA's National Aviation Facilities Experimental Center launched a small program to investigate a data link developed by Stromberg-Carlson, a division of General Dynamics Corp. The system operated at only about 1/15th the data rate of the RCA system, but it had certain compensating advantages.

Program Priorities

Until recently FAA has treated the RCA system as its mainstream effort, with the Stromberg-Carlson system assigned a lower priority as a research investigation. This spring, in view of growing pressures from ATA, which liked certain features of the Stromberg-Carlson system, FAA decided to give the latter equal priority with the RCA program and to install both equipments in the same aircraft for simultaneous evaluation.

ATA's statement on AGACS says that the airlines believe that neither the present RCA system nor the existing Stromberg-Carlson system meet the operational requirements for a suitable data link, but that a system which combines the best features of each would be nearly ideal.

The RCA system permits extremely high-speed data rates, 750 bits per second, enabling it to transmit and receive messages from 250 aircraft per minute over a single channel. The RCA AGACS is an outgrowth of a military data link developed for use with Air Force interceptors and the Bomarc missile.

The Stromberg-Carlson system employs techniques similar to those used for teletype, with a data rate of about 50 bits per second. Studies indicate that it can transmit and receive fixed-format (preselected) messages from 60 aircraft per minute per channel. Because of the slower data rate, the Stromberg-Carlson system is directly compatible with, and can be tied into, teletype circuits and facilities.

ATA outlined 17 basic requirements last week which the airlines believe are needed for a suitable AGACS system. Although many of these reflect the desires of U.S. airlines, others are intended to make the AGACS system compatible with facilities and practices of foreign countries, to facilitate international adoption, ATA said.

ATA Requirements

Some of the basic requirements which ATA sees for an operational data link system include:

- **Flexible message format:** System should be capable of transmitting unusual or non-routine messages in addition to routine ones, somewhat in the fashion of teletype. As presently designed, RCA system handles only fixed-format messages, but the company reportedly is investigating possibility of variable-format messages at FAA request. Some observers believe that this ATA requirement is not justified because voice communications can be used for such non-routine messages.
- **Voice data multiplex:** Single VHF transmitter/receiver should be able to simultaneously handle both voice and data communications, ATA believes. Present RCA system is designed to use existing (recent vintage) VHF com-

New View of Aeroflot Turboprop An-24

Twin Ivchenko 2,000-eshp. turboprop installations are shown in this new view of the Soviet An-24 feederliner designed for Aeroflot service (AW June 13, p. 39). Soviets claim that new lightweight construction methods have been used in the An-24 to increase performance and payload capacity. Aircraft is designed to cruise at 325 mph. at 20,000-ft. altitude. The An-24 seats 40 passengers in high-density configuration.

munications transmitter/receiver, but it does not permit simultaneous voice and data transmission/reception. Stromberg-Carlson technique permits simultaneous voice/data communications.

• **Offset carrier network operations:** To permit U. S. system to be used abroad, it should be able to operate with a network of VHF stations which transmit simultaneously, each at a carrier frequency only slightly different (few kilocycles) from adjoining stations. The RCA system, with its high data rate and short pulse length, would have more difficulty in operating with this type network than would the slower speed Stromberg-Carlson system.

Despite ATA's stand that it does not favor either of the two systems now under FAA test in their present configurations, the Stromberg-Carlson techniques fit into ATA requirements more easily than do the RCA techniques. Some observers believe that ATA will run into strong counter-arguments over some of the requirements it has set forth.

ATA and FAA representatives met last week at the agency's Atlantic City facility for detailed discussions of the airline requirements.

The Air Transport Assn. statement emphasizes that it considers an automatic data link system "of considerable operational urgency" and urges continued high-priority effort to development of a suitable system.

House Group Approves Mail Airlift Prohibition

Washington—A bill that would prohibit the movement of mail by air unless it carries airmail postage was approved last week by a House Post Office and Civil Service Subcommittee.

The bill, which came out of the subcommittee with the strong support of the railroads (AW June 13, p. 45), was amended to exempt Alaska, Hawaii and U. S. territories and to specifically include the District of Columbia.

During the closing hours of testimony before the special subcommittee, the bill drew sharp opposition from representatives of four airlines, the Post Office Department, Air Transport Assn. and the Association of Local Transport Airlines.

Stuart G. Tipton, president of the Air Transport Assn., told the subcommittee that the Postmaster General has clear authority to move all classes of mail by air and added:

". . . To remove that authority would be to turn back the clock. It would be, as far as I know, the first time our Post Office Department, or for that matter the postal service of any country, retrogressed to a slower means of transportation."

Eastern Pilots Strike in Protest To FAA's Jet Check-Ride Stand

New York—Eastern Air Lines' flights were cut to a trickle last week by a walkout of its pilots that was continuing despite a court order mailed last Tuesday to all the pilots ordering them back to work.

American Airlines, Pan American World Airways, and Trans World Airlines were operating normally last Thursday after they won a restraining order requiring their pilots to stay on the job instead of walking out in accordance with a Tuesday night deadline set by Air Line Pilots Assn. The dispute is between the pilots and Federal Aviation Agency Administrator Elwood Quesada's order that FAA inspectors occupy the third pilot's seat when check-riding on Douglas DC-8 schedules (AW June 13, p. 43).

The Eastern pilots' walkout is without the sanction of ALPA and is in defiance of a Miami U. S. District Court restraining order which was extended last Tuesday. Eastern said it attempted to reach its pilots by phone and telegram to give them their flight assignments, but had little success. The walkout assumed almost total proportions early last week.

Two Eastern pilots were cited for contempt of court in Miami, but the citations were dropped. ALPA counsel had sought a jury trial for the pilots, but Eastern objected to this. The citations were voided on technical grounds connected with the serving of the restraint orders.

Two officers of the Eastern pilots' Miami ALPA council have submitted their resignations.

The striking pilots claim their action was spontaneous and virtually unanimous. Some of them brand Quesada "a virtual dictator who makes rules at will and changes them at will regardless of safety considerations." It is the pilots' contention that shifting the third pilot from his accustomed seat makes it impossible for him to perform his duties satisfactorily and so jeopardizes safety. Quesada's position is that the jets are certificated to operate safely without the third pilot, and that the FAA inspectors cannot do their jobs adequately from a back seat in the cockpit.

In New York, about 350 Eastern pilots held a meeting last Tuesday under the auspices of a "back to work committee." Several of those attending this meeting told AVIATION WEEK that the pilots would not go back to work "under the shadow of an injunction."

Possible reprisal against the pilots who walked out was cited as a possible stumbling block to working out a solution.

The pilots want Eastern to back up their stand against Quesada by agreeing that safety requires the third pilot to be in his own seat.

Malcolm A. MacIntyre, the airline's president, said Eastern was not interested in reprisals against those who had turned down flight assignments "under intimidation." The airline contends that the large majority of its pilots are being prevented from flying by the intimidation of "a small group of pilots" determined to close down the airline as a "massive protest" against FAA regulations.

One pilot summed up the strikers' position this way: Training and crew operation are oriented around a four-man crew (including the flight engineer) on the jets, and shifting the third pilot disrupts normal procedures. One way out of the impasse might be to set aside Quesada's regulation temporarily and have it reviewed by all parties concerned, he said, and added that Eastern should itself refuse to operate until such a step is taken.

If the walkout were to be called off immediately, this pilot said, there would have to be no reprisals—Eastern would have "to let bygones be bygones."

It is not the desire, but the responsibility, of the pilots to walk off trips which they consider unsafe, according to these spokesmen.

An ALPA headquarters spokesman said ALPA was "very surprised" at the Eastern pilots' action and the Eastern pilots had been notified of ALPA's disapproval. "Bad laws are better than anarchy," the spokesman said.

Eastern's position in the seat dispute is that while it is desirable for the third pilot to keep his seat, moving him to another position does not in any way affect safety.

Eastern's operation had dwindled from 52.1% of scheduled plane miles flown on June 11 to 12.98% on June 14. System-wide passenger total was 13,316 on June 11, fell to 3,782 on June 14. The first flight out of Miami since midnight, June 10, was made last Wednesday by a regional vice president of ALPA, who brought an Electra into Newark. This pilot flew another Electra from Idlewild to Miami last Thursday.

The pilots' contract with Eastern came up for renegotiation Apr. 1, and last direct negotiations were held in May. Mediation has been requested.

Bilateral Issues Threaten Route Growth

By L. L. Doty

Washington—Growing tension between the U. S. and foreign nations on commercial aviation issues now threatens to bring to a halt the historic expansion of U. S. international air routes and services.

The recent breakdown in talks between the U. S. and Britain—officially a "recess"—spotlights the increasing demands for a bigger share of traffic for foreign flag carriers serving U. S. markets (AW June 13, p. 38). A number of other issues—particularly route adjustments—enter into the over-all international controversy, but an analysis of negotiations between the U. S. and Britain last spring at Barbados (AW Mar. 21, p. 25) suggests that capacity lies at the root of the problem.

The Barbados talks are significant, since they involved the two countries which developed the principles contained in the text and clauses of the Bermuda Agreement, the bilateral air transport pact on which all subsequent civil air agreements negotiated by the U. S. were based. These talks and their outcome may have set a pattern for the many foreign carriers demanding that a proviso restricting seat capacity offered in scheduled services accompany any exchange of routes on a bilateral basis.

Such a condition is not necessarily in violation of Bermuda principles. The capacity clauses in the Bermuda Agreement establish a firm relationship between the capacity provided by a carrier and the traffic requirements of the routes served by that carrier. These clauses open a "fair and equal opportunity" to each contracting party by permitting both carriers to promote new traffic by offering adequate service, yet preventing one carrier from absorbing a quantity of traffic that would be detrimental to the other carrier.

Although it is not specifically spelled out in the clauses, it is possible for either country to ask for a review of traffic activities at any time to determine whether capacity offered is in line with the Bermuda principles.

Capacity Clauses

In effect, the capacity clauses can be interpreted to permit wide freedom of operation in open competition or tight control of operations to protect national interests. This permits each country to adjust schedules according to existing conditions through consultation. Because of this flexibility, the Bermuda Agreement is likely to hold its position as the standard blueprint for all bilaterals in the foreseeable future.

The fact remains, however, that this wide gap in interpretations sets sharply defined battle lines in forthcoming negotiations. Since the two diverse views represent two virtually incompatible philosophies, stalemates are inevitable if a compromise can't be reached.

Meanwhile, it is now becoming evident that the U. S. may be forced to comply with many of these demands for capacity restrictions since it is no longer armed with the bargaining power it once held when international routes were in the initial stage of development. Most foreign flag carriers now hold air carrier permits to serve U. S. ports of entry and are asking for additional cities within the U. S. as a fair exchange for any new routes sought by the U. S.

Such an exchange of routes has already drawn violent protests from domestic carriers, who charge that the addition of foreign flag carriers on domestic routes will have serious diversionary effects on domestic traffic. This situation has left State Department teams negotiating bilateral agreements without any inventory of bargaining tools.

Loss of bargaining power coupled with demands by foreign nations for capacity restrictions have been mainly responsible for the serious deadlocks in negotiations which have confronted the U. S. this year. This situation is illustrated by an inside look at the talks between the British and the U. S. which began in Barbados Feb. 23 and ended without agreement on Mar. 16.

Barbados Session

The U. S. delegation entered into negotiations with the United Kingdom at Barbados without any clue as to British aims. Of some 11 items on the U. S. agenda, Civil Aeronautics Board placed top priority on the proposed extension of Northwest Airlines' transpacific route into Hong Kong. As a result, the State Department delegation introduced this issue as an opening gambit in the first formal session.

Second item of importance in the U. S. program was Trans World Airlines' long-sought extension of its London-Frankfurt route into Zurich, to close a gap in European routes. The U. S. was prepared to offer the British a San Francisco-Fiji-Australia route in exchange. Addition of Jamaica-San Juan services to Delta Air Lines' Caribbean route structure was ranked third in priority by the Board.

Other items included cabotage (AW Apr. 13, 1959, p. 38), multiple designations and the controversial Section IV(b) of the Bermuda Agreement (AW Apr. 27, p. 38). In essence, Section IV(b) permits either party to add intermediate points on established routes not in the territory of the other party on simple notification to the other party.

The CAB recommended a revision of this section which would restrict its application to points within a country's own borders under a zoning system. If the U. S. failed to reach an agreement with the British on this revision, it was then to press for an interpretation of the section which would specifically confine the addition of cities to "minor" points only.

At the opening session of the conference, the British agreed to tackle the Hong Kong issue as the first item on the agenda, but only after losing a strong bid to make the Caribbean area the first point of discussion. The Hong Kong talks barely got off the ground before the session was bogged down in a prolonged interchange of views on capacity.

Hong Kong Dispute

The British argued over the technicalities involved in the extension of Northwest's routes, although they did not question the U. S. right to multiple designation of carriers into Hong Kong. They pointed out that Seattle and Portland, terminal points on Northwest's transpacific route, are Section IV(b) points and that the route, therefore, was not part of the transpacific route established in the annex of the Bermuda Agreement and could not be extended.

Principal stand, however, was that a major capacity problem already exists on Far East routes and that Pan American's schedules into Hong Kong have already created excessive capacity which would only be compounded by the addition of Northwest services.

The British, nevertheless, were willing to consider a new Seattle-Tokyo-Hong Kong route for Northwest if an agreement on capacity could be reached and other issues brought before the meeting were settled. U. S. held to its stand that it wanted Hong Kong rights for Northwest with no strings attached.

The proposal left U. S. delegates faced with a number of uncertainties as to the direction in which the meeting was headed. Generally, it was believed by the delegates at this stage that some sort of package offer was in the making.

On the third day of the meeting, the British continued to express concern over capacity. They enlarged upon their proposal for a new Northwest route by attaching these four conditions to their offer: no beyond points out of Hong Kong, agreement on capacity, final settlement on intermediate points and

UAT to Fly DC-8 Between Paris-Johannesburg

Douglas DC-8 ordered by the French airline Union Aeromaritime de Transport (UAT) will begin service to Africa on Sept. 10, flying between Paris, Dakar, Abidjan, Douala, Brazzaville, Salisbury and Johannesburg. The jet transport is undergoing final assembly at Douglas' Santa Monica, Calif., plant. UAT has ordered two DC-8s for delivery in 1960.

agreement on all issues brought before the meeting.

During the fourth day, the Hong Kong issue was temporarily shelved and the delegates were presented with other agenda items to consider over the weekend. The Frankfurt-Zurich route for TWA was turned down sharply, but the British reacted more cordially than expected to proposed U.S. cargo rights between London and Paris.

Following the weekend, the delegates reconvened on the seventh day. U.S. went on record with a request to have Amsterdam and Brussels established as points beyond London for Pan American and Hanover for Seaboard & Western. This was followed by some discussion as to how far the conference should go into the European route problem at this time.

The British rejected proposals for any basic revisions in Section IV(b) and suggested that the "gentlemen's agreement" of 1956 be applied to the addition of cities under IV(b). The agreement calls for confining all such cities to minor points. This statement led to an argument as to how "minor" should be defined.

Sessions were adjourned on the seventh day to permit the delegates to visit the Mardi Gras in Trinidad. On the 10th day, the meeting confined its discussion to the Caribbean area. TWA group in Barbados during the meeting made a strong bid for its Frankfurt-Zurich route by arranging a private talk with the head of the British delegation. Eleventh day sessions were also confined to Caribbean routes, with the British tacitly indicating that there was very little wanted from the U.S. in exchange for growing U.S. route requests.

It became apparent on the 11th day that the British had turned cool to the idea of a London-Paris route for the U.S. At this point, it was proposed that the conference move to Washington because of the serious communications problems in Barbados. On the 15th day, there were signs that the British had lost some of their enthusiasm over moving the conference to Washington.

Revision or elimination of Section IV(b) came up on the 16th day as a bargaining tool, with both sides indicating that they might support elimination of the section under certain circumstances. The U.S. held that it would favor removal of the section from the bilateral if routes were adjusted to satisfy long-term requirements prior to elimination of the section.

U.S. held back any concessions on South Pacific routes until the TWA Frankfurt-Zurich problem could be settled. The British conceded a London-Paris segment for Seaboard & Western for cargo only. Other cargo-only concessions were made for Seaboard & Western which drew sharp protest from Pan American following the conference. The latter held that granting of exclusive rights to Seaboard was contrary to the principles of multiple designation and that such rights should be granted to all other carriers transporting cargo.

The concluding seven days of the meeting brought no firm conclusions or compromise. The Hong Kong issue remained unsettled. TWA was advised that the granting of a Frankfurt-Zurich link would be economically harmful to British European Airways in the view of the British. TWA was offered Cairo as a beyond point from Frankfurt but the carrier rejected this route as an unsatisfactory substitute for the Zurich leg.

Attempts to get the British to agree to a three-carrier operation, on an all-cargo basis only, between London and Paris failed. Caribbean route structure problem was not resolved.

CAB Alters Findings On Albuquerque Crash

Washington—Civil Aeronautics Board issued a third report last week on the 1955 crash of a Trans World Airlines Martin 404 near Albuquerque, N. M., blaming the accident on "deviation from the prescribed flight path for reasons unknown."

After its original investigation, the Board issued a report finding the accident was probably caused by lack of conformity with prescribed en route procedures and deviation from airways at an altitude too low to clear obstructions. The transport hit Sandia Mountain while en route from Albuquerque to Santa Fe. The mountain was on the direct course between the cities, while the prescribed course was a dog-leg around the mountain.

The report was controversial, and CAB took a second look. The second report, issued in 1957, carried the same probable cause, but the Board changed its earlier statement that the crew flew the direct course across the mountain intentionally.

In 1958, the Air Line Pilots Assn. gave the CAB Bureau of Safety some facts and theoretical information which led CAB investigators to make a third trip to the accident site. After reviewing all the data again, the Board decided to alter its finding a second time.

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SHORTLINES

▶ **Civil Aeronautics Board** and Federal Aviation Agency appointments of retired military officers have been attacked by Sen. Clair Engle (D.-Calif.) in a Senate speech. Specifically mentioned were the appointments of Gen. John S. Bragdon as a member of the CAB and several officers serving under FAA Administrator E. R. Quesada. Sen. Engle said that "the generals who are running the civilian agencies . . . reach out and pull in all their old 'buddies,'" and that serving under Quesada, a retired USAF general, were 14 colonels, nine lieutenant colonels, one Navy commander, three Navy captains and three brigadier generals.

▶ **Continental Airlines** reports it has carried 335,000 passengers more than 411 million revenue passenger miles and flown more than 3,670,000 cargo ton miles in its first year of Boeing 707 service. The company said 707 utilization averaged 10 hr. 34 min. daily during the first year. Present scheduling calls for daily utilization of 12 hr. 45 min. per aircraft.

▶ **Oakland, Calif.,** Board of Port Commissioners has called for bids on the Metropolitan Oakland International Airport terminal building to be built at an estimated cost of $4,725,000. Federal Aviation Agency has allocated $1,555,000 for the project, the rest being raised from general obligation bonds and revenue bonds. The terminal will have 175,000 sq. ft. of floor space.

▶ **Pan American World Airways** will resume and expand flights on its Great Circle route between San Francisco and Tokyo July 1 using Boeing 707-321 turbojet aircraft. Service over the route was inaugurated Nov. 16, 1959, but westbound service had to be suspended Feb. 10 because of turbojet problems.

▶ **United Air Lines** will increase seating capacity on its West Coast-Honolulu routes by nearly 80% beginning July 15. Service between the Hawaiian Islands and the mainland this year will total 30 round trips a week, all with Douglas DC-8 turbojet transports.

▶ **Soviet Union's** major foreign aid project in Afganistan includes construction of a 33,000 sq. ft. international terminal building at Kabul Airport.

▶ **Western Air Lines** has opened a new Mexico-Latin America sales office in downtown Los Angeles to meet growing interest in travel to Latin America from Western cities.

AIRLINE OBSERVER

▶ Domestic trunkline traffic continued to climb during May, but the increase fell far short of the upward monthly trend established through 1959. In addition, first-class revenue passenger miles showed a 2.6% decline during the month, with a jump of 12.2% in coach traffic accounting for the overall increase of 6.5% in passenger traffic. Load factors held firm throughout the month, since most carriers enforced rigid control over capacity. Total passenger load factor for the 12 trunklines was 59%—a one point drop from load factor in May, 1959. First-class available seat miles rose only .6% to give the carriers a first-class load factor of 57%, compared with 59% in the same month last year. Coach available seat miles climbed 19.3% for a 60% load factor, identical with the figure reported in May, 1959.

▶ **Watch for a move by Federal Aviation Agency to change policy on the allocation of costs of relocating air navigation facilities. At the present time, FAA covers such costs as part of its airways maintenance program. Under the revised policy, such costs will be considered airport improvement and will be paid for by airport operators.**

▶ Export-Import Bank of Washington has authorized a $25.5 million credit to the government of Australia to cover part of the purchase price of three Boeing 707-138B transports for delivery to Qantas in 1961. Cost of the three aircraft, plus installation of turbofans on Qantas' seven 707s and other modifications, totals $40 million. Boeing Airplane Corp. will finance $4.5 million of the purchase price, and the $10 million balance will come from Australian financial sources.

▶ **American Airlines is making a test case out of the Civil Aeronautics Board decision in the Washington-Baltimore Adequacy of Service Case in which the carrier was told to add at least one daily flight in the Baltimore-Dallas market and confer with the Board and other carriers as a means of achieving "voluntary adjustment of schedule timing." In a petition, American questioned the Board's authority to supervise schedules and said the decision carried "broader, long-range implications which threaten literally to wreck the domestic airline system."**

▶ Airline employment has passed the 165,000 mark, highest total yet achieved, according to the Air Transport Assn. Total of 10,000 new jobs was created last year through the introduction of turbine equipment, and average airline employe earnings last year exceeded $6,500, compared with $4,573 for full time employes in all industries, according to the association.

▶ **Eastern Air Lines has removed all-black finish on noses of its Douglas DC-8 turbojet transport fleet. Eastern found that sharply angled nose of the DC-8 eliminates glare normally encountered on other aircraft models.**

▶ Convair Division of General Dynamics Corp. last week announced price increases on the Convair 880 and 600 turbojet transports ranging from 4 to 4½% of present base prices, which are $3.8 million for the 880 and $4,360,000 for the 600.

▶ **Multilateral agreement has been signed by 10 European nations setting standards on airworthiness of aircraft. Purpose of the agreement is to facilitate export and import of aircraft from one state to another. Nations include France, Finland, Ireland, Italy, Luxemburg, Portugal, Spain, Sweden, Switzerland and the United Kingdom.**

▶ Federal Aviation Agency has taken delivery of the Boeing KC-135 tanker which was purchased for use in the agency's high-altitude airways research and test program.

▶ **Pan American World Airways has had an 84% increase in traffic on its Seattle-Honolulu route during the past six months it has been operating the route with Boeing 707-320 turbojet transport flights, compared with the same period last year when the route was served by piston-engine aircraft.**

▶ American Airlines has been granted a 200-hr. flight time extension on its Pratt & Whitney JT3C-6 turbojet engines by the Federal Aviation Agency. Flight time between major overhauls is now set at 1,300 hr.

PRESENT FACILITIES at O'Hare International Airport are largely temporary. Jets of several airlines are part of scene above.

Jets Spur Shift From Midway to O'Hare

By Glenn Garrison

Chicago—Mass operation of jet transports at O'Hare International Airport has brought about a rapid shift of airline schedules away from crowded Midway Airport, a move long desired by the City of Chicago but long resisted by the carriers.

Midway is still the world's busiest commericial field, but O'Hare, formerly unpopular because it is about twice as far from the city as Midway, has felt an influx of traffic since last fall that now has its temporary facilities bursting at the seams. A $120 million construction program is under way at O'Hare but completion is not expected before 1962.

All of Chicago's jet operation, which began early last year and began getting really heavy last fall, is handled at O'Hare.

During the first four months of last year, about 378,049 passengers used the airport. In the same period of 1960, this total was up by almost a million. At the same time, Midway's passenger total for the period dropped 766,000 from 3,148,880 in the first four months of 1959.

Here are the passenger traffic figures (arrivals and departures) for both airports from 1955, when first scheduled operations began at O'Hare Field:

	Midway	O'Hare
1955....	9,135,074	64,806
1956....	8,864,268	704,691
1957....	9,438,481	1,016,854
1958....	9,336,029	1,261,376
1959....	10,063,316	2,146,268
1960.... (4 months)	2,383,019	1,361,100

The O'Hare traffic, already running way ahead of predictions, is expected to almost double this year over last. By 1965 O'Hare will, by some estimates, handle about three-quarters of the two-airport total.

Before the jets arrived, most airlines had been slow to move schedules from overcrowded Midway. A major objection was the problem of connections: perhaps 60% or more of Chicago's passengers are making connections from one plane to another. Moving a flight to O'Hare, therefore, cut it off from the great number of connecting services at Midway, except for arduous ground connection or helicopter. Chicago-based passengers naturally preferred the shorter ground run to Midway, so load factors generally were poor at O'Hare on the flights that were shifted there. Sometimes flights were moved over to O'Hare and then back again when load failed to build up.

United, which set up its own network of connections, started the big switch last fall when about half its Chicago flights were put into O'Hare. The other trunklines serving Chicago have been following suit as more and more jet schedules are added. In April, 1959, daily arrivals and departures averaged 94; last April, the total was 272.

Another cause for airline hesitation to move, of course, was their large investment in facilities at Midway.

Airlines and passengers alike will have rough going at O'Hare in some respects this summer and during the period of transition, as jet schedules increase and construction adds to the confusion. As Chicago's commissioner of aviation, William E. Downes Jr., told AVIATION WEEK, "It will be tough to keep everybody happy during this time." Downes pointed out that some building will be taking place in the area of the field where passenger operations are in full swing, causing traffic and parking problems among others.

Main problem now is this one of coordination and construction, Downes said, since "we're over the hump as far as financing is concerned."

Chicago sold $120 million in O'Hare par value revenue bonds in March, 1959, to finance the airport improvements. The investment is in effect underwritten by the carriers, the terms of whose contracts guarantee that debt service will be paid and facilities amortized.

Proceeds from sale of the bonds aggregated $118,277,833, which, with interest on investments, provides a total of $121,435,745. After disbursements of $17,050,991, the fund's balance at Apr. 30, 1960, was $104,384,754.

Downes said two years of hard negotiations have resulted in "a splendid job for the community" with a new facility which will carry itself financially. All commercial jet traffic is expected to operate at O'Hare, the commissioner said, and he questions whether Midway will handle even small jet transports.

The 6,600-acre O'Hare includes enough land so that runways can be provided with clear zones of 2,700 ft. on airport property. Runway 14R-32L, now 8,838 ft., is in the process of extension to 11,600 ft. and could go to 15,000 ft. with a 2,700-ft. clear zone.

Other elements of the construction program include terminal and cargo buildings, hangars, and a hydrant fueling system. Schedule calls for completion of the terminal complex by Jan. 1, 1962. To date, work on some terminal buildings and hangars has begun and other projects in progress include fuel tanks and various utilities.

The ground transportation situation will be improved with completion of a new expressway connecting the airport with Chicago. Running time, according to Downes, will be about 25 min. There are various reports of present ground time, with a figure of 1½ hr. recurring. The new, stoplightless expressway is scheduled for completion by next January.

Nine trunklines serve O'Hare—American, Braniff, Capital, Delta, Continental, Eastern, Northwest, Trans World, and United—all but two of them now operating jets at the field. The present exceptions are Capital and Northwest, and Northwest expects to begin jet service next month. Internationally, Air France, British Overseas, Lufthansa, Pan American, Trans-Canada and TWA offer schedules.

Air France and Lufthansa had been serving Midway with piston equipment but recently moved to O'Hare with their new jet aircraft.

North Central, the only local service carrier now at O'Hare, moved a few flights over a couple of years ago. It now operates about 23 daily schedules at O'Hare, compared with 89 at Midway. North Central's facility at O'Hare "operated as a poor farm" for a while, according to Frank N. Buttomer, vice president-traffic and sales. Flights went out with two or three passengers aboard. The ground transportation problem, Buttomer said, was worse for a local service airline because of the shorter flight times involved. Local business was lost in some cases to train services. However, the jets are developing their own business, Buttomer said, and North Central's load factors at O'Hare are much better.

Other local service carriers will follow North Central in shifting flights to O'Hare and some may move their entire operation.

Current forecasts of future O'Hare traffic by Chicago's Department of Aviation, in terms of enplaned passengers, indicate a 95% increase in 1960 to a total of 2,100,000 departures. For next year, the forecast is 2,940,000 enplaned passengers. By 1965 the total is expected to reach 6,820,000.

Fast Landing Cited in Capital Crash

Washington—Civil Aeronautics Board last week found that the probable cause of a Capital Airlines Lockheed Constellation 049 accident at Charleston, W. Va., May 12, 1959, was due to the pilot landing the aircraft too fast on a wet runway under conditions conducive to aquaplaning.

The aircraft was intentionally ground looped on the landing, but, during the maneuver, it slid down a steep embankment beyond the boundary of the runway. One of 38 passengers and one of six crew members died in the fire which followed the accident. One passenger was seriously burned.

According to testimony given during the accident investigation, the aircraft touched down within the first third of the runway, but when it failed to respond to braking, the pilot ordered the first officer to raise flaps to put weight on the wheels and increase traction. The first officer did not hear the order.

When it became evident that the airplane could not be stopped within the limits of the runway, the captain decided to attempt a left ground loop and called for full power on No. 4 engine. The engineer misunderstood the command and applied power to all four engines.

When the plane failed to ground-loop, the pilot saw the error and quickly closed throttles on engines one, two and three. The Constellation then made its ground-loop to the left, but the maneuver began too late to remain within the airport boundaries.

In its conclusions, the Board questioned the delegation of the handling of power controls by the flight engineer during an emergency landing. Admitting that the power to delegate is discretionary with the captain, the Board stated it "believes that in this instance this was not optimum procedure and that instead the handling of throttles by the captain may well have resulted in less disastrous results."

FUTURE LOOK of O'Hare Field after $120 million construction program is completed in 1962 is indicated above. Work is under way.

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Local Airlines List Officers' Salaries

Washington—Following is a list of local service airline officers' and directors' salaries, bonuses and indirect compensation, expenses and stock holdings for the year ending Dec. 31, 1959, as reported to the Civil Aeronautics Board.

Allegheny Airlines, Inc., (carrier did not list bonuses or indirect compensations)—**L. O. Barnes**, president and director, $29,250 salary, $4,731 expenses and 25,900 shares of common stock; **W. J. Short**, vice president-finance, $17,950 salary, $1,450 expenses and 250 shares of common stock; **D. L. Miller**, senior vice president-sales and director, $18,450 salary, $2,506 expenses and 502 shares of common stock; **R. G. Dinning**, vice president-flight and passenger services, $16,500 salary, $1,295 expenses, 400 shares of common stock and 100 shares of common stock in name of others; **R. J. Masiello**, vice president-maintenance and engineering (entered office 4/28/59), $12,819 salary, $2,397 expenses and no stock.

E. I. Colodny, secretary (entered office 4/28/59); $13,500 salary, $2,164 expenses and 100 shares of common stock; **W. D. Hay**, controller, $10,000 salary, $334 expenses and no stock; **G. F. Gerth**, treasurer, $10,300 salary, $409 expenses and 200 shares of common stock; **V. F. Fountains**, assistant secretary, $5,700 salary, $73 expenses and no stock; **L. L. Stentzel II**, assistant secretary (entered office 4/28/59), no salary, $29 expenses and no stock; **E. K. Arnold**, vice president and secretary (resigned (5/6/59), $8,736 salary, $597 expenses and no stock; **J. S. Russell, Jr.**, assistant secretary (resigned 4/28/59), no salary, expenses or stock.

Following directors did not receive a salary: **C. F. Bidelspacher, Jr.**, $49 expenses and no stock; **R. F. George**, $1,560 expenses, 52,100 shares of common stock and 1,000 shares of common stock in name of others; **H. O. Hale**, chief counsel and director, $177 expenses and 2,500 shares of common stock; **H. H. Hallowell**, $85 expenses and 1,000 shares of common stock; **R. M. Love**, $58 expenses and 1,000 shares of common stock in name of others; **P. V. Mattes**, $196 expenses and 5,000 shares of common stock; **W. F. Rockwell, Jr.**, $208 expenses and 15,000 shares of common stock; **H. A. Satterwhite**, chairman of the board, $307 expenses, 9,075 shares of common stock and 3,900 shares of common stock in name of others; **H. B. Sharp, Jr.**, no expenses and 1,700 shares of common stock.

Following firms were paid for services rendered during 1959: **Hale, Stimson, Russell & Nickerson**, legal, $39,418; **R. Dixon Speas Assoc.**, engineering services and technical evaluation of equipment, $22,932; **Robert M. Gamble, Jr., Inc.**, advertising, $16,022; **Van Sant Dugdale & Co.**, advertising, $142,637.

Bonanza Air Lines, Inc., (carrier did not list bonuses or indirect compensations)—**E. Converse**, president and chairman of the board, $20,000 salary, $1,166 expenses and 211,061 shares of common stock; **G. R. Henry**, executive vice president and director, $17,834 salary, $4,461 expenses and no stock; **M. W. Reynolds**, vice president-operations, $17,625 salary, $1,457 expenses and no stock; **W. J. Mitchell**, vice president-sales, $13,217 salary, $3,850 expenses and 100 shares of common stock; **R. J. Sherer**, treasurer, $13,217 salary, $1,965 expenses and 200 shares of common stock; **R. O. Hawkins**, general counsel and secretary (entered office 1/5/59), $11,000 salary, $878 expenses and no stock; **E. C. Jochim**, director-research and development and assistant secretary, $11,917 salary, $809 expenses and no stock; **W. C. Burt**, assistant secretary, no salary, no expenses and 1,400 shares of common stock; **T. J. Van Bogart**, assistant treasurer, $6,084 salary, $360 expenses and no payment of stock.

Following directors were paid a director's fee in lieu of a salary and were not paid expenses: **F. W. Beer**, $200 fee and 6,080 shares of common stock; **B. Converse**, no fee and 16,500 shares of common stock; **C. M. Glass, Jr.**, $200 fee and 1,000 shares of common stock; **W. Pabst**, $200 fee and no stock; **G. L. Vargas**, $200 fee and 8,770 shares of common stock; **W. T. Waggoner, Jr.**, no fee and 33,943 shares of common stock.

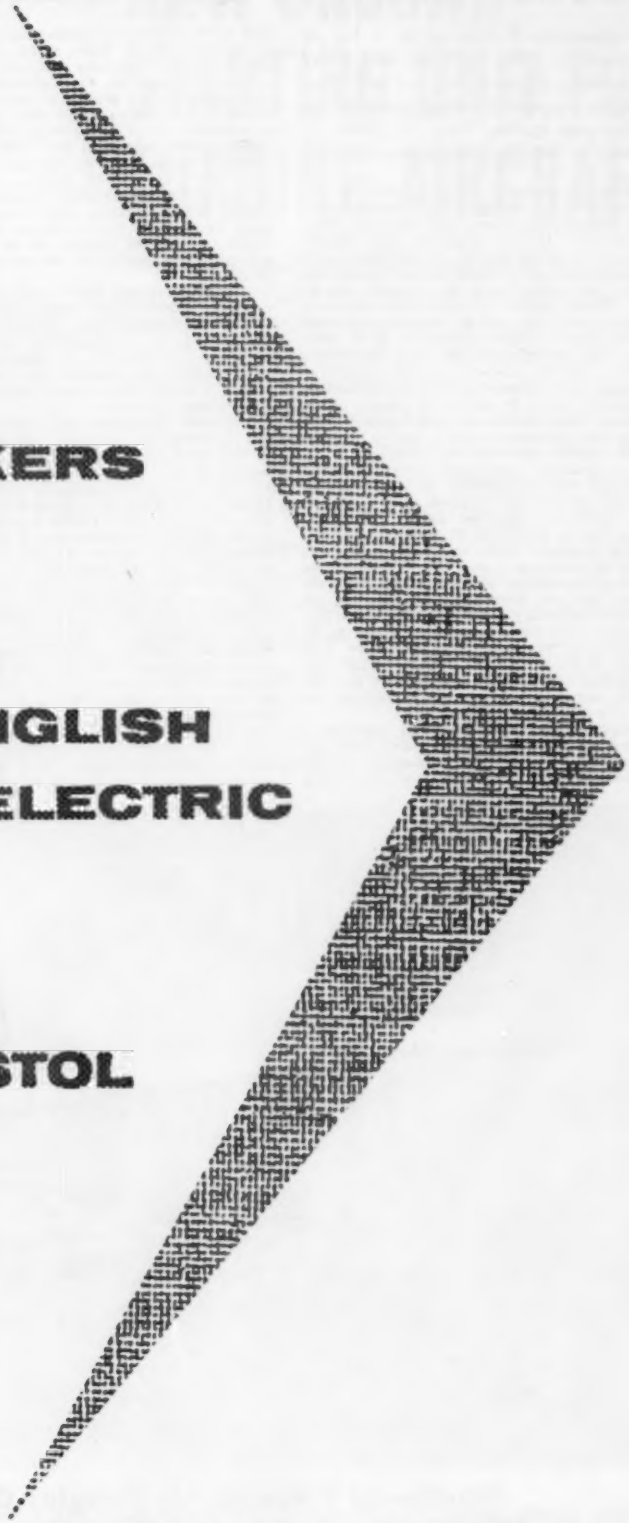
Following firms were paid for services rendered during 1959: **Koteen & Burt**, legal counsel, $17,566; **Vargas, Dillon & Bartlett**, legal counsel, $16,751; **Albert F. Grisard**, legal counsel, $6,785; **Gibson, Dunn & Crutcher**, legal counsel, $15,350; **Peat, Marwick, Mitchell & Co.**, financial audit, $7,300.

Central Airlines, Inc., (carrier did not list bonuses or indirect compensations)—**K. Kahle**, president and director, $18,000 salary, $5,870.31 expenses and 26,004 shares of common stock; **F. E. Howe**, executive vice president, treasurer and director, $17,000 salary, $994.16 expenses and 1,500 shares of common stock; **R. L. Wageneck**, vice president-operations and director, $16,000 salary, $815.94 expenses and 500 shares of common stock; **A. S. Aldridge**, vice president-traffic and sales and director, $13,000 salary, $1,560.69 expenses, 2,196 shares of common stock and eight shares of preferred stock.

C. E. Lundstrom, secretary and assistant treasurer, $10,000 salary, $414.07 expenses and 553 shares of common stock; **A. H. Pritchett**, assistant secretary, $5,842.50 salary, $44.48 expenses and 279 shares of common stock; **B. Gahagan**, assistant secretary, $5,242.50 salary, no expenses and 400 shares of common stock; **F. K. Johnson**, chairman of the board, $8,000 salary, $10.78 expenses and 143,239 shares of common stock; **P. Crawford**, assistant secretary, $600 salary, no expenses or stock; **W. Whitlock**, chief pilot, $13,258

Northwest Prepares for Douglas DC-8 Service to Tokyo

First of five Douglas DC-8 turbojet transports ordered by Northwest Airlines will start New York-Tokyo service July 8 and Seattle/Tacoma-Tokyo service on July 12. New York-Tokyo elapsed time will be 16 hr. 31 min., and from Seattle/Tacoma the route will take 12 hr. 31 min. The New York service includes a stop at Anchorage, Alaska. Powerplants are four Pratt & Whitney JT4A-9 engines, each developing 16,800 lb. thrust.



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Negotiations have been completed with the Hunting Group for British Aircraft Corporation to acquire a controlling interest in Hunting Aircraft.

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salary, on expenses or stock.

Following firms were paid for services rendered during 1959: **Pogue & Neal**, legal, $31,182.26; **Mueller & Mueller**, labor consultant, $20,248.46; **Marvin, Gwinn & Assoc.**, advertising agency, $37,067.24; **E. H. Pickering**, research consultant, $10,483.44.

Frontier Airlines, Inc., (carrier did not list bonuses or indirect compensations)—**L. B. Maytag, Jr.**, chairman of the board and president (assumed presidency 1/13/59), $16,500 salary, $2,089.86 expenses and 493,601 shares of common stock; **C. A. Myhre**, president and director (resigned 1/13/59), $14,732.40 salary, no expenses and 20,100 shares of common stock; **G. R. Woody**, executive vice president (entered office 5/1/59), $18,333 salary, $195.42 expenses and no stock; **L. P. Blatter**, treasurer and vice president (assumed vice presidency 1/13/59), $13,462 salary, $2,392.99 expenses, 80 shares of common stock and 25 shares of common stock in name of others.

J. D. Brock, vice president (entered office 6/29/59), $7,846 salary, $646.73 expenses and no stock; **J. D. Lindsay**, vice president (resigned 2/31/59), $7,511.36 salary, $431.81 expenses and no stock; **H. P. Barnard, Jr.**, vice president (entered office 1/13/59), $13,375 salary, $606 expenses and 225 shares of common stock; **J. A. Love**, secretary and director, no salary, $144.45 expenses and 122 shares of common stock; **C. Post**, assistant secretary (resigned 2/27/59), $1,374.24 salary, $216.92 expenses and no stock; **D. W. Rausch**, assistant treasurer (entered office 2/16/59), $8,580 salary, $1,066.04 expenses and 10 shares of common stock; **E. W. Sexton, Jr.**, (resigned 2/13/59), $2,363.89 salary, $6 expenses and no stock; **E. B. Slocum**, no salary, $600 fee for services on executive committee, no expenses or stock; **L. W. Linville**, director, no salary or expenses and 550 shares of common stock; **P. Walker**, no salary or expenses and 50 shares of common stock.

Following firms were paid for services rendered during 1959: **Harry A. Bowen**, legal, $24,414; **Rippey, Henderson, Buckman & Co.**, advertising agency, $184,678.34.

Lake Central Airlines, Inc.—**Dr. R. B. Stewart**, chairman of the executive committee and director (entered office 4/14/59), no salary, $2,900 director and trustee fees, no expenses and 1,500 shares of common stock; **J. J. O'Connell**, chairman of the board $2,400 salary, $2,100 director and trustee fees, $458.70 expenses, 1,666 shares of common stock. O'Connell was authorized as voting trustee to vote 80,954 shares of stock under the trust which represents 43% of stock. The voting trust contract was terminated 3/15/60.

G. Hicks, president and director, $18,499.86 salary, no fees, $11,424.84 express, and 6,532 shares of common stock, including some shares voted under the trust contract; **L. W. Hartman**, executive vice president and director, $18,499.86 salary, no fees, $1,905.97 expenses and 5,900 shares of common stock, including some shares voted under the trust contract; **W. H. Krieg**, secretary and directory, no salary, $300 director and trustee fees, no expenses and 1,678 shares of common stock, including some shares voted under trust contract.

R. W. Callifford, vice president and director, $15,611.42 salary, no fees, $1,110.95 expenses and 2,839 shares of common stock, including some shares voted under the trust contract; **H. Goff**, chief pilot and director, $14,050.55 salary, no fees, $435.15 expenses and 1,500 shares of common stock, including some shares voted under the trust contract; **A. E. Sabo**, flight captain and director, $14,238.41 salary, no fees, $195.13 expenses and 4,230 shares of common stock, including some shares voted under the trust contract; **D. S. Getchell**, vice president, $12,749.88 salary, no fees, $448.36 expenses and 1,333 shares of common stock, including some shares voted under the trust contract.

J. L. Cory, assistant treasurer, $10,442.16 salary, no fees, $416.45 expenses and 4,100 shares of common stock including some shares voted under the trust contract; **A. F. Grisard**, assistant secretary, no salary, fees or expenses and 4,181 shares of common stock, including some shares voted under the trust contract; **J. R. Carr, Jr.**, assistant secretary, no salary, $50 director and trustee fees, no expenses and 509 shares of common stock not involved in trust contract; **R. P. West**, assistant secretary, no salary, fees or expenses and 1,233 shares of common stock, including some shares voted under the trust contract.

Following directors did not receive a salary: **J. D. Peterson**, $1,200 director and trustee fees, no expenses or stock; **C. A. Berry**, $350 director and trustee fees, no expenses or stock; **E. McC. Blair**, $600 director and trustee fee, $138.37 expenses and 16,700 shares of common stock not involved in trust contract; **W. E. Chope**, $100 director and trustee fees, no expenses or stock; **W. W. Brown**, $100 director and trustee fees, $65.01 expenses and 2,000 shares of common stock not involved in trust contract.

Following firms were paid for services rendered during 1959: **Albert F. Grisard**, legal, $31,028.47; **Buschmann, Krieg, DeVault & Alexander**, legal, $14,664.42 (total of payments listed as having been paid over several years); **Leon A. Sprague** legal, $16,374.40 (total of payment listed as having accumulated over several years); **Charles Murphy**, legal, $8,034 (total of payment listed as having accumulated over several years).

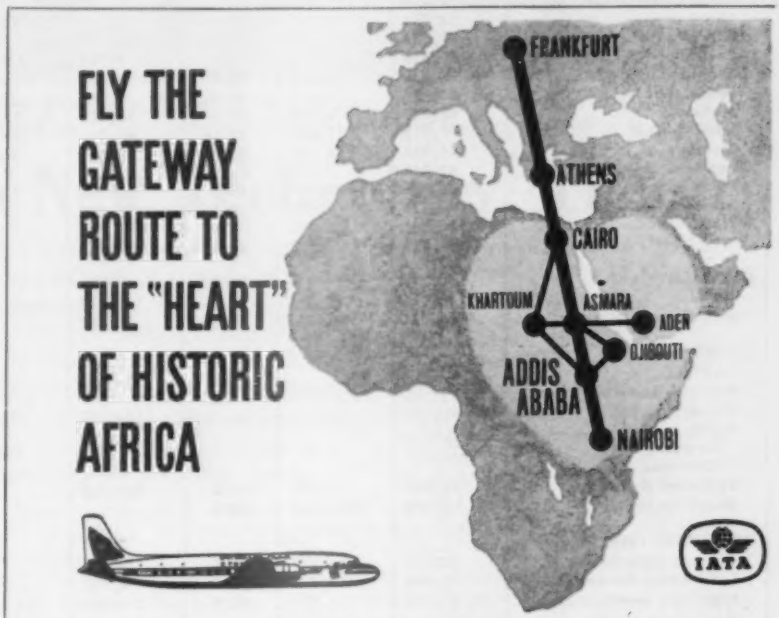
Mohawk Airlines, Inc., carrier did not list bonuses or indirect compensations—**R. E. Peach**, president and director, $32,000 salary, $6,190 expenses, 10,000 shares of capital stock and $27,000 in debt securities; of capital stock and $2,000 debt securi- $24,500 salary, $2,758 expenses, 4,018 shares of capital stock and $2,000 in debt securities; **C. A. Benscoter**, vice president and director, $24,500 salary, $2,699 expenses, 3,782 shares of capital stock and $5,000 in debt securities; **T. J. Kirkup**, vice president (resigned 12/31/59), $13,000 salary, $1,926 expenses, 1,600 shares of capital stock and $10,000 in debt securities; **D. E. Pestle**, vice president (resigned 4/30/59), $4,500 salary, $284 expenses and no stock or debt securities.

E. V. Underwood, chairman of the board, $4,500 salary, $561 expenses, 3,000 shares of capital stock and $1,000 in debt securities; **F. B. Chabot**, treasurer, $15,500 salary, $1,226 expenses, 100 shares of capital stock and no debt securities; **B. C. McLean**, secretary, $10,677 salary, $1,903 expenses, no stock and $500 in debt securities; **R. J. Longwell**, assistant treasurer, $9,667 salary, $1,448 expenses, 12 shares of capital stock and no debt securities; **L. P. Hornbrook**, assistant secretary, $5,300 salary, $499 expenses, 16 shares of capital stock and no debt securities.

H. R. Thomas, assistant secretary, $6,867 salary, $1,232 expenses, 15 shares of capital stock and no debt securities; **R. V. Stephenson**, vice president (entered office 4/30/59), $11,500 salary, $2,212 expenses, 150 shares of capital stock and no debt securities; **R. R. Taylor**, assistant vice president (entered office 4/30/59, $13,000 salary, $1,076 expenses, 254 shares of capital stock and no debt securities.

Following directors were not paid a salary or expenses, with one exception: **B. J. Miner**, 133 shares of capital stock and no debt securities; **C. N. Silcox**, 2,000 shares of capital stock and no debt securities; **W. J. Fields**, 1,000 shares of capital stock and no debt securities; **E. A. Link**, 24,111 shares of capital stock and $125,000 in debt securities; **P. A. Schoellkopf**, no stock or debt securities; **C. F. Johnson, Jr.**, (ceased to be a director in October, 1959) five shares of capital stock and no debt securities; **J. C. Corwith**, no stock or debt securities; **W. V. Daugherty**, 2,500 shares of capital stock and $7,000 in debt securities; **C. W. Sorrell**, $10 expenses, 151 shares of common stock and no debt securities; **D. B. Billings** (became director 4/30/59), no stock or debt securities; **H. W. Harding** (became director 4/30/59), no stock or debt securities.

Following firms were paid for services rendered during 1959: **Gilfoil & McNeal**, public accounting, Securities and Exchange Commission filing and systems study, $11,876; **Pogue & Neal**, legal, $15,222; **Alexander & Green**, legal, $7,593.



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ETHIOPIAN AIRLINES

THE WONDERLAND ROUTE

Airline Traffic—April, 1960

	Revenue Passengers	Revenue Passenger Miles (000)	Passenger Load Factor %	U. S. Mail Ton-Miles	Express Ton-Miles	Freight Ton-Miles	Total Revenue Ton-Miles	Over-all Revenue Load Factor %
DOMESTIC TRUNK								
American	699,098	509,229	66.2	1,961,916	996,622	9,041,103	60,843,611	57.4
Braniff	189,270	88,910	55.8	412,125	152,164	573,529	9,663,250	45.3
Capital	333,174	143,576	56.7	588,310	276,188	450,253	15,066,591	51.6
Continental	107,431	68,515	52.2	162,821	109,176	302,248	7,148,924	42.1
Delta	289,493	165,161	63.1	441,362	285,583	1,352,677	17,973,524	52.3
Eastern	727,200	397,767	57.09	1,252,666	523,414	1,700,649	41,784,395	46.29
National	158,000	111,216	59.7	316,279	67,468	632,229	11,763,341	46.1
Northeast	123,857	55,523	58.4	143,924	34,810	187,768	5,678,774	50.3
Northwest	156,227	112,635	52.8	666,189	274,649	1,598,191	13,323,608	46.7
Trans World	427,445	364,183	64.5	1,542,213	653,087	3,150,959	40,253,057	54.8
United	597,870	410,678	65.4	2,843,616	962,697	6,176,454	49,379,956	59.1
Western	138,172	73,810	58.1	344,897	96,036	352,333	7,868,948	51.7
INTERNATIONAL								
American	9,637	10,352	63.1	8,387	438	211,206	1,286,586	64.2
Braniff	4,652	9,930	49.9	35,793	.....	115,628	1,234,050	44.4
Caribbean Atlantic	33,971	2,379	66.8	2,110	.....	7,970	261,746	70.1
Delta	2,554	3,459	39.1	6,958	.....	31,896	415,253	37.3
Eastern	39,752	56,651	61.90	106,124	.....	152,215	6,082,580	60.67
Mackey	13,524	2,288	45.7	.....	239	6,014	252,735	42.3
National	2,313	1,802	38.4	2,882	2,201	17,662	216,881	35.3
Northwest	15,385	27,918	47.4	1,318,530	15,020	1,071,327	5,362,740	52.8
Pan American								
Alaska	5,069	5,191	45.9	39,260	.....	183,137	766,171	44.9
Atlantic	118,747	154,787	70.1	1,382,362	.....	4,012,390	21,670,489	61.6
Latin America	92,932	109,256	66.9	427,918	.....	4,095,609	15,389,853	65.2
Pacific	33,236	115,930	73.4	1,899,659	.....	2,366,608	16,414,840	63.4
Panagra	10,274	13,765	54.5	82,936	.....	520,074	2,099,657	59.1
Resort	.....	.....	.....	.....	.....	3,517,521	3,517,521	82.3
Trans Caribbean*	.....	.....	.....	.....	.....	.....	.....	.....
Trans World	28,423	78,868	68.6	1,176,136	.....	1,154,782	10,577,513	62.9
United	11,806	29,283	80.0	190,733	11,627	141,063	3,321,158	60.7
Western	4,718	7,337	69.9	8,190	.....	31,335	812,190	73.6
LOCAL SERVICE								
Allegheny	54,733	10,463	47.7	14,810	26,605	37,312	1,076,823	45.7
Bonanza	23,486	5,787	44.5	8,197	3,123	12,227	579,236	45.9
Central	14,553	2,742	39.8	7,744	3,063	11,031	284,983	36.2
Frontier	27,528	7,303	38.7	26,139	9,491	61,591	801,232	42.9
Lake Central	20,376	3,164	40.0	5,182	20,436	.....	328,227	44.0
Mohawk	42,493	8,496	52.5	16,982	12,915	15,497	854,582	48.6
North Central	79,213	13,662	42.66	42,365	38,675	34,222	1,438,419	43.66
Ozark	49,968	8,480	43.5	16,632	24,649	27,643	880,359	47.2
Pacific	42,363	9,785	51.7	17,180	4,497	8,567	963,354	48.0
Piedmont	39,814	8,183	46.8	10,189	13,507	17,014	828,083	48.0
Southern	27,838	4,979	33.7	15,512	12,129	17,383	522,402	35.2
Trans-Texas	26,526	6,192	38.6	23,344	12,518	40,010	668,160	38.9
West Coast	32,649	7,647	44.11	13,931	5,313	13,376	762,942	44.01
HAWAIIAN								
Aloha	28,901	4,264	61.1	2,619	.....	6,267	342,228	54.2
Hawaiian	43,074	9,219	59.9	85,684	.....	334,730	1,236,365	56.5
CARGO LINES								
AAXICO	.....	.....	.....	.....	.....	6,072,614	6,072,614	67.41
Aerovias Sud Americana	.....	.....	.....	.....	.....	532,910	532,910	86.4
Flying Tiger	.....	.....	.....	164,197	64,526	14,645,987	14,874,700	71.2
Riddle								
Domestic	.....	.....	.....	26,033	28,039	1,330,658	1,384,730	67.4
Overseas	.....	.....	.....	5,991	.....	481,974	487,965	67.5
Seaboard & Western	2,761	10,724	100.0	548,763	.....	3,279,145	4,913,923	64.9
Slick	2,279	Not Listed	100.0	.....	.....	8,419,800	8,895,335	100.0
HELICOPTER LINES								
Chicago Helicopter	28,131	477	56.3	1,235	.....	.....	46,778	41.0
Los Angeles Airways	3,301	115.6	60.7	4,751	2,292	.....	18,101	67.3
New York Airways	13,472	270	57.1	1,895	1,318	587	29,576	56.8
ALASKAN LINES								
Alaska Airlines	9,835	8,071	56.6	76,805	3,681	344,590	1,211,318	63.3
Alaska Coastal	3,916	407	53.0	3,945	.....	4,619	50,383	58.8
Cordova	1,289	341	40.9	3,744	.....	40,037	78,554	46.7
Ellis	4,495	277	51.6	4,394	.....	6,340	39,777	74.1
Northern Consolidated	2,273	694	32.7	47,097	.....	60,156	182,633	54.4
Pacific Northern	7,725	6,932	37.3	116,109	6,509	271,000	1,148,013	50.3
Reeve Aleutian	1,527	1,378	36.1	44,176	.....	75,602	270,558	56.0
Western Alaska*	.....	.....	.....	.....	.....	.....	.....	.....
Wien Alaska	3,302	679	35.7	51,910	.....	104,830	226,536	48.6

* Not available.

Compiled by AVIATION WEEK from airline reports to the Civil Aeronautics Board.

SAC IN TRANSITION
Special Report on STRATEGIC AIR COMMAND

SYMBOL of transition for SAC are North American Hound Dog missiles on wings of these Boeing B-52G bombers of the 4135th Strategic Wing, Eglin AFB, Fla. The missiles—two each per bomber—portend SAC's trend away from long range bomber as its only weapon.

SAC Reacts to New Technology, Threat

Strategic Air Command is beginning a decade of transition aimed at molding its deterrent capability to meet the challenge of a rapidly expanding technology and a shifting international equation.

For the first 15 years of its existence, SAC was built around a single weapon—the long range bomber carrying nuclear bombs. During this period, SAC pursued a single line of development, moving to faster, longer ranging aircraft better able to penetrate potential enemy defenses with heavier nuclear loads. This policy brought SAC to a position where for the past decade it has been—and still is today—the most powerful military force the world has ever known.

Operating from this position of unchallenged military superiority today, SAC's real problems lie with tomorrow. From this single line of technical development its weapons are fanning out into a wide technical spectrum that already includes supersonic bombers, combinations of bombers with missiles, intercontinental ballistic missiles, and will soon reach out into military space systems.

From what was basically a long range bomber command SAC is now beginning its transition into a strategic aerospace force.

Primary and most difficult job of SAC is to deter any potential aggressor from embarking on ventures that would lead to major war. This is the element of SAC's mission that requires the greatest urgency in developing and integrating new weapons into its aerospace force-in-being and the greatest skill in deploying and using these forces short of armed conflict.

"Any fool can get in a war," Gen. Thomas S. Power, commander-in-chief, told Congress, "but it takes a smart man to stay out of one on his terms."

Secondary mission of SAC is, in the event deterrence fails, to win any war that starts.

Both of these missions involve essentially the same requirements since to successfully deter any potential aggressor it must be made abundantly clear to him that he cannot possibly win any war he may be tempted to start.

Deterrent capability is neither fixed nor finite. It is a fluid, ever-changing equation that varies with weapons, tactics, leadership quality and national strategy.

It also consists of more than purely military powers since much of an aggressor's evaluation of the deterrent confronting him will rest on his assessment of his opponent's determination to use the military power available.

Today SAC provides the capability for delivering over 90% of the nuclear striking power of the Free World, measured in TNT equivalents. To do this job SAC gets about 20% of the total Defense Department annual budget dol-

GEN. THOMAS S. POWER, SAC commander-in-chief, in the cockpit of a Boeing KC-135.

lars, has 10% of the total aircraft, 7% of the personnel and uses 9% of its real estate and property.

Defining the concept of what composes genuine deterrent capability is at the root of many of SAC's problems during this period of transition since they cannot be effectively solved without adequate understanding by the legislative and executive branches of government and the American people.

One Major Error

One major error in measuring deterrent capability is to use as a yardstick the amount of damage that would deter the U.S. from embarking on a nuclear interchange. The accurate yardstick has to be what would deter the leaders of the Soviet Union from a similar prospect. It should be obvious that these are two widely different standards. The Soviets killed more of their own citizens in implementing the collectivization of agriculture than the U.S. lost in battle casualties in World War II. The greatest civil disasters that have ever hit this country are infinitesimal compared with the famines that have swept Russia and China in modern times. The Soviet Union lost about 20 million people, most of its prewar industrial capacity and two-score of its major cities in World War II. Yet it not only survived as a nation but won the war and 10 years later had bounced back to the position of second most powerful force in the world.

"The closest man who would know what the maximum deterrent is would be Mr. Khrushchev," said Gen. Power, "and frankly I don't think he knows from one week to another. He might be willing to absorb more punishment next week than he does today. Therefore minimum deterrence is not a concrete or finite amount . . . If anybody tells you that they know what the minimum deterrent is, tell them for me they are liars."

Another grave error in measuring deterrent capability is to consider it the force available before an enemy's initial attack rather than what will be able to survive the effect of the actual attack.

About 99% of SAC's nuclear weapons delivery capability rests today in the bomb bays of its 2,000-odd B-47 medium jet bombers and B-52 heavy jet bombers, but its deterrent capability rests in the Soviet's estimate of how many of these bombers would survive an initial attack and be able to mount a retaliatory counter strike.

During the next few years SAC is programed to deploy 27 squadrons of Atlas and Titan ICBMs in a variety of sites with varying degrees of hardness, dispersal and reaction time. These will be made a significant addition of SAC's nuclear delivery capability and will add significant speed to its retaliatory lash. But the measure of the deterrent capability of this force of close to 300 ICBMs rests not in this original emplaced strength but in what portion of this force will survive an initial enemy salvo and be capable of being launched toward Soviet cities.

Thus the total force-in-being five years hence of bombers on the alert line and ICBMs on their pads might be impressive to an American citizenry that did not understand the genuine values in the deterrent equation. But its survivability factor might be so low in Soviet estimates that the prospects of winning a nuclear interchange at the relatively low price that could be inflicted by the fractional surviving force of SAC might be attractive to Kremlin planners.

Survivability Insurance

It is SAC's task to ensure within the limits of the resources provided by Congress and the executive branch of the government the maximum survivability of its force-in-being at any given moment during this transitional period.

As SAC entered its decade of transition, 99.9% of its nuclear weapons were carried in the bomb bays of its B-47 and B-52 fleet, and the major threat to its survivability still came from the Soviet's manned bomber fleet of turboprop Bears and turbojet Bisons, with a minor threat to SAC's overseas deployment from Soviet IRBMs emplaced in western Russia and the maritime provinces of Siberia.

SAC was well configured to meet this threat. Its heavy bomber fleet was based behind three radar warning nets —the DEW Line covering the polar cap, the Mid-Canada Line and the Pine Tree Lines across the northern tier of the United States—with both Atlantic and Pacific flanks protected by Texas towers and airborne radar stations.

This warning net could give SAC at least 2-3 hr. to get its counterforce into the air and on its way. A normal alert status was sufficient at advanced bases in Europe, Alaska, Guam and Africa.

Its striking force was switched in size and configuration to get off the ground within the 15 min. warning that the NATO early warning system could provide.

With SAC's system of positive control for its airborne combat-ready aircraft it is possible to launch the bomber fleet without having positive incontrovertible evidence of an enemy attack and still have the capability of automatic recall if the "go-code" is not received by the airborne bombers before they have flown a certain period. Decision to transmit the "go-code" through the chain of command from the President of the U.S. through the Joint Chiefs of Staff to SAC Headquarters can be pondered during this period before the automatic recall situation is reached without impairing the strike capability of the airborne fleet.

Soviet Capability

With the advent of the Soviet ICBM capability, this picture is changing rapidly. At the moment, SAC will get no warning of any ICBM attack. Even with the completion of the Ballistic Missile Early Warning System (BMEWS) the possibility of a 15 min. warning is not sufficiently firm to permit configuring SAC's bomber reaction to this margin.

SAC faces the job of developing survivability tactics that will work successfully without any warning. To meet this requirement, SAC has developed the airborne alert concept and has tested the operational feasibility of keeping up to 25% of its heavy bomber force in the air at all times, where they cannot be reached by any enemy surprise attack with ICBMs.

Since the bulk of SAC's retaliatory power will still be carried in bomb bays during the next five years, the airborne alert is the key to SAC's survivability in sufficient force to remain an effective deterrent.

Airborne alert tactics have been developed and proved in test exercises but the capability of putting a significant portion of the heavy fleet on a continuous airborne alert requires stockpiling spare engines, electronic gear and other spares, more crews for both tankers and bombers, and heavy expenditures for fuel. Most of these are all long lead time items.

Initial Funds

Initial funds for these spare procurements have been released and some efforts are under way to provide SAC with the resources it will require to implement an airborne alert when necessary. Major contention between SAC and higher echelons in the Defense Department still is over the size of the alert force capability to be developed.

The growing operational force of Atlas and Titan ICBMs will offer little counter-force possibility even with an authentic 15 min. warning from BMEWS because it is highly improbable that any command to launch ICBMs at enemy targets will be given until actual impacts are recorded on U.S. soil. SAC feels its liquid-fueled ICBM force will have to ride out any enemy missile salvo and be hardened and dispersed sufficiently so that its surviving ICBMs can more quickly follow the airborne alert force toward enemy targets.

In addition to ensuring survivability of its bomber and missile force, SAC's problem in the swiftly shifting deterrence equation of its transitional period is whittling down the enemy's possibilities of knocking out its retaliatory capacity by increasing, dispersing and complicating the target system it presents.

Working from published statistics, it was relatively simple to compute that last January there were only about 100 installations and facilities from which the U.S. could launch nuclear armed aircraft or missiles. All of these were "soft" sites that would take heavy damage even from a near miss of enemy nuclear weapons.

This relatively small target system, Gen. Power calculated, could be crippled by a strike of approximately 300 missiles (150 IRBMs and 150 ICBMs), allowing three missiles to each target to achieve a 90% probability of taking the target out. At that time there was no proof that the Soviet actually had 150 ICBMs emplaced on pads, and Gen. Power used this only as a hypothetical example of the military attractiveness such a prospect would present for a foreign power, with this missile capability balanced against such a relatively small strategic target system and spurred by aggressive desires.

New Additions

SAC is adding to its target complex by new dispersal bases for its heavy bomber wings, but the most significant additions to any enemy target system will come from the Atlas and Titan force now beginning to be deployed in the western states. These ICBM sites, each with a hardening and dispersal factor within each complex, will increase geometrically any enemy ICBM launch requirements for any prospect of success in a surprise attack. SAC's second priority next to achieving the airborne alert capability is to increase the size, hardening and dispersal of its Atlas force in the 1962-63 period when additional Atlas production could be translated into a larger hardened force.

The arithmetic of missile site configuration changes in raising the enemy's initial strike requirements is startling. Using anticipated CEPs from ICBMs, the dispersal of Atlas to 9 to 1 squadron sites triples the enemy's initial ICBM strike force requirement while hardening of Atlas and Titan dispersed sites multiplies this requirement by 10. Hardened and dispersed ICBM sites can survive within the fireball radius of a multi-megaton warhead impact and can be destroyed only by a direct hit.

By the mid-1960s SAC will be approaching another phase in its transition. Its initial striking power will be almost equally balanced between its bomber fleet with air-launched missiles and the ICBMs in the Atlas and Titan complexes. But with this mixed force-in-being, it will be able to add another major factor in the deterrent equation with the introduction of the solid-fueled Minuteman ICBM. The Minuteman, because of its relatively low cost, long storability and instantaneous reaction capability, will complicate the Soviet target problem with another quantum jump in dispersal and hardening plus the complicating factor of mobility through the use of missile trains moving at random over the western network of railroads.

Survivability Factor

With this mixture available by the mid-1960s, the survivability factor of SAC should increase significantly at the same time any enemy's targeting requirements for a surprise missile attack would increase geometrically beyond the relatively modest 100-target "soft" site complex of six months ago.

During this transitional period SAC must maintain a margin of survivable deterrent capability with its weapons mix and tactics that is unquestionably superior to the combined enemy resources for initial surprise strike and his defensive resources to blunt or parry the SAC counter-strike. If this margin of superiority is allowed to be whittled down to where it is debatable for any given time period a dangerous "deterrent gap" can develop.

SAC believes that the maintenance of a continuously effective deterrent capability depends on constantly improving weapons, increasing flexibility of tactics and keeping the survivability factor of its mixed force so high that only irrational desperation could tempt an aggressor into testing it. Exercising this deterrent capability is similar to a stud poker game where enough high cards must be played face up to convince any opponent that the strength of the hand is authentic, but with just enough hole cards face down to prevent diagnosis of exactly how the hand will be played. It is a difficult game, with the cost of each card rising, the stakes increasing, and the price of running an unsuccessful bluff nothing less than survival.

GANTRY lights go on at dusk for around-the-clock operations of three operational Atlas intercontinental ballistic missiles at Vandenberg

SAC Shapes Missile Force for Survival,

Intercontinental ballistic missiles (ICBMs) are the fulcrum of Strategic Air Command's major transition into an expanding technical spectrum of weapons. As SAC moves into its initial and relatively small operational ICBM capability during 1960, it is also heading down the road toward a major transition within the ICBM field. It is progressing from the exposed and unprotected Atlas of its initial operational capability at Vandenberg AFB through five variations of liquid-fueled ICBM deployment, offering evolutionary improvements in survivability, guidance accuracy, warhead potency and reaction time toward the ultimate goal of the mobile, hardened and widely dispersed solid-fueled Minuteman, capable of almost instantaneous reaction.

The full transitional period from initial soft-site, liquid-fueled Atlas missiles at Vandenberg to the beginning of an operationally significant hardened and widely-dispersed Minuteman capability will be roughly five years although development and installation activities on all of the Atlas, Titan and Minuteman variants is proceeding concurrently.

Operational Problems

As the first U.S. military force to grapple with the operational problems of the ICBM, SAC is discovering that its initial training operations at Vandenberg are already feeding back information leading to major improvements in future deployment, maintenance and operation of this type of weapon. Although the initial soft-site Atlas squadrons may represent a debatable military asset in assaying the over-all deterrent capability, SAC believes they are serving two useful purposes. The first is the evolutionary data they are contributing to the operations of the later hardened ICBM complexes and the second is that they do enlarge any potential enemy's surprise attack target requirements.

In its transition through the Atlas and Titan technical and operational evolution, SAC will move from the initial gantry-serviced, soft installations now on 15-min. operational alert capability at Vandenberg, to a "coffin" shelter installation that permits maintenance and servicing work on the missile in a horizontal position, held in place on an erector in a rectangular concrete enclosure with a hydraulically actuated movable roof. The "coffin" type of installation resulted from experience of SAC crews working on the exposed gantries in the raw salt winds off the Pacific at Vandenberg, a problem that was not readily apparent in the milder climate of the development testing operations at Cape Canaveral, Fla. Working on open gantries loomed as increasingly impossible in the frigid winter climates of Colorado, Wyoming and Montana, where many of the initial ICBM sites are programed. Later versions of the "coffin" installation will be reinforced to withstand relatively minor blast damage from a nuclear weapons attack.

Initial Atlas sites also are vulnerable because of the above-ground antenna installations of the combination radio-inertial guidance systems which are too long to harden. Initial Atlas squadrons are also clustered in a three-missile-to-a-site complex in the nine-missile squadron, again due to guidance system considerations.

Atlas Capability

Switch to all-inertial guidance makes possible dispersal to a nine-site Atlas squadron, with each missile situated at sufficient intervals to make vital damage to more than one site per enemy missile hit unlikely. This Atlas capability is still an evolutionary step toward the 12 missile squadrons, with each missile encased in a concrete silo built to withstand anything but a direct hit by a multi-megaton warhead. Atlas, which is the first USAF ICBM to reach an operational status, is currently programed for 13 squadrons with further increases being considered in the Fiscal 1961 defense budget to augment the size of the later hardened squadrons and add several additional squadrons.

Titan is programed for 14 squadrons (see box on p. 106). Coming along later than Atlas in the operational picture, Titan will begin directly with hardened silo, dispersed installations that also

AFB, Calif. Center missile stands free from its gantry in firing position. Atlas can deliver a thermonuclear warhead over 6,000 mi.

Fast Reaction

harden the guidance system antenna. Later Titan squadrons will switch to all inertial guidance and utilize storable non-cryogenic fuels that will give the missile a faster reaction time and make possible firing from inside the silo.

Major reductions in launch and maintenance personnel are possible with improved versions of both Atlas and Titan. For example the five man launch crew required for earlier model Atlas squadrons will be reduced to three-man crews in the all-inertial guidance units. Shift from Titan Mark I to the Mark II will make possible a reduction in squadron personnel from 600 to 300 men.

SAC has been making initial ICBM deliveries to operational sites by truck but MATS is developing an airlift capability for both Atlas and Titan with a growing fleet of Douglas C-133B turboprop transports equipped with specially enlarged cargo doors that permit loading of either a complete Atlas without vernier engines installed or both stages of the Titan in a single load. USAF eventually plans to concentrate truck deliveries on short hauls from the contractors' San Diego and Denver plants and to utilize the C-133B fleet for longer-haul operations. All critical maintenance parts are delivered from supply depots or direct from the manufacturer by the Air Materiel Command Logair cargo plane system.

All of the hardened and dispersed Atlas and Titan squadrons will represent a permanent addition to SAC's total deterrent posture, although their reaction time may be slower than that of the solid-fueled Minuteman. They will also offer a permanent advantage in hurling a multi-megaton warhead, with considerably more yield than the solid-fueled missiles, for special targets. Initial Titan operational capability is scheduled for achievement next year.

In the meantime USAF Ballistic Missile Division, working closely with SAC through its SAC Mike group at BMD headquarters and the First Missile Division at Vandenberg AFB, is developing the operational techniques for the initial Minuteman installations—both the in-silo firings from hardened, widely dispersed, 50 to a squadron fixed sites and with the missile trains that will provide Minuteman with mobility, moving over a random pattern of the nation's railroad network with the capability of launching on extremely short notice.

SAC feels that the emplacement of Minuteman silo sites and deployment of mobile missile trains in significant quantity during the mid-1960's will provide a missile target system that would raise any enemy requirement for a successful initial surprise attack aimed at wiping out this mixed missile force to a prohibitive level both from the total resources required and the operational feasibility of such a strike.

The Minuteman period represents the era when SAC feels that the bulk of its deterrent capability will shift from the bomb bays of its manned vehicles to the warheads of fixed and mobile ICBMs. Major reduction in the cost of the solid-fueled Minuteman over the larger, more complex, liquid-fueled, first generation ICBMs will make it possible for USAF to procure and install this weapon in sufficient quantities to present a virtually insoluble target problem for any potential enemy.

Current development progress with the Minuteman program indicates that SAC may get its initial capability in this solid-fueled ICBM by late 1962 or early 1963, considerably earlier than originally anticipated.

All but one of the SAC ICBM base sites already announced are west of the Mississippi River, away from the heavy industrial and population areas of the eastern half of the country. Basic SAC policy in picking ICBM sites was contingent on accessibility to potential targets with the more than 7,000-mi. range of the operational Atlas and Titan providing this requirement from well into the southern tier of states; soil conditions suitable for sinking silos of the hardened complexes; and utilization of existing SAC base support facilities. SAC has some sites where both bombers

and missiles will continue to use the same basic support facilities and feels that the expense of building new base support facilities exclusively for ICBM bases is an unsupportable budget policy.

SAC has run into mixed reaction from the population centers adjacent to its announced ICBM sites. They range from the basic pacifist protests staged by religious groups at Omaha through pleas for a larger portion of missile expenditures by civil groups in Cheyenne, who hope to have the Union Pacific marshaling yards and repair facilities utilized in the Minuteman program in addition to the fixed ICBM sites; to the attitude of a Tucson group which has campaigned for a shift in the ICBM sites there to a prevailing downwind location in relation to the city. Tucson, like Cheyenne, recognizes the heavy economic fallout into the community from the ICBM base construction and operational program. But this civic group in Tucson wanted SAC to move the sites to the opposite side of the town where the winds for 80% of the year would carry any potential radioactive fallout away from the city.

Vandenberg AFB, headquarters of the First Missile Division commanded by Maj. Gen. David Wade, is the current hub of SAC missile activity. Vandenberg's mission is threefold:

• **Development testing.** Ballistic Missile Division is building one of each type of Atlas, Titan and Minuteman launching complexes at Vandenberg for final development testing of the complete missile system, in contrast to its earlier research and development test phase at Cape Canaveral, Fla. The prototype of each missile installation that will eventually go into service with SAC gets its final checkout to work out its operational "bugs" at Vandenberg.

• **Training.** All SAC ICBM crews will be trained at the Vandenberg complex (AW Mar. 7, p. 93) to operate their particular type of missile from the specific type of launch complex to which they will be assigned. First crews for the operational missile squadrons at Warren AFB near Cheyenne already have made their initial Atlas firings from Vandenberg, and a steady stream of SAC operational missile personnel will soon be coming out of the USAF Training Command missile specialist schools at Vandenberg, where for the first time the missile and its launch crew are brought together with ground support equipment, site environment, maintenance and logistics systems for integrated weapon system training.

Live Launch

This training is usually climaxed by a live launch across the Pacific Missile Range to the instrumented splash net bullseye at Wake Island, 3,900 naut. mi. and 26 min. 29 sec. Atlas flying time from the Vandenberg pads. The Wake bullseye consists of a 20-mi. circular web of underwater hydrophones that accurately measure the exact impact point of the missile warhead. Another similar bullseye system is currently being installed near Eniwetok with a cable link between the two systems to permit accurate scoring anywhere between these two points.

• **Operational.** First SAC operational ICBM capability was achieved at Vandenberg in the fall of 1959 with a complex of three, soft-site Atlas missiles. Vandenberg's operational role is in the process of expanding from its original limited program with a total of 100 sq. mi. available for hardened, dispersed sites for up to 100 ICBMs of various types, according to Gen. Wade.

"What we are doing at Vandenberg with the ICBM," says Gen. Wade, "is the equivalent of USAF's entire development of bomber aircraft from the B-17 to the B-52. And we have to do it all in a few short years."

Initial integrated weapons system training and operational experience at Vandenberg are fast rewriting SAC's initial book on ICBM operations and significantly changing launching, maintenance and supply procedures to fit more rigid operational requirements of close to 100% combat readiness for on site missiles and a constantly diminishing reaction time.

Next missile site to achieve operational status will be at Francis E. Warren AFB near Cheyenne, Wyo. The first strategic missile squadron here is a soft configuration of two clusters of three missiles each, known as a 3 x 2 configuration. It will possess SAC's initial all-operational capability. At Warren, as at other SAC missile installa-

CONVAIR ATLAS

BASE	LOCATION	NO. SQDS.	CONF.	TOTAL MISSILES
*Vandenberg AFB	Santa Maria, Calif.	1	Soft	Varying
†F. E. Warren AFB	Cheyenne, Wyo.	3	soft 3x2	6
			soft 3x3	9
			semihard	9
Offutt AFB	Omaha, Neb.	1	soft 3x3	9
Fairchild AFB	Spokane, Wash.	1	semihard 1x9	9
Forbes AFB	Topeka, Kan.	1	semihard 1x9	9
Schilling AFB	Salina, Kan.	1	hard 1x12	12
Lincoln AFB	Lincoln, Neb.	1	hard 1x12	12
Walker AFB	Roswell, N. M.	1	hard 1x12	12
Dyess AFB	Abilene, Tex.	1	hard 1x12	12
Altus AFB	Altus, Okla.	1	hard 1x12	12
Plattsburgh AFB	Plattsburgh, N. Y.	1	hard 1x12	12
				123

* now operational
† operational 1960

MARTIN TITAN I

*Lowry AFB	Denver, Colo.	2	hard 3x3	18
Beale AFB	Marysville, Calif.	1	hard 3x3	9
Mountain Home AFB	Mountain Home, Idaho	1	hard 3x3	9
Larson AFB	Moses Lake, Wash.	1	hard 3x3	9
Ellsworth AFB	Rapid City, S. D.	1	hard 3x3	9

MARTIN TITAN II

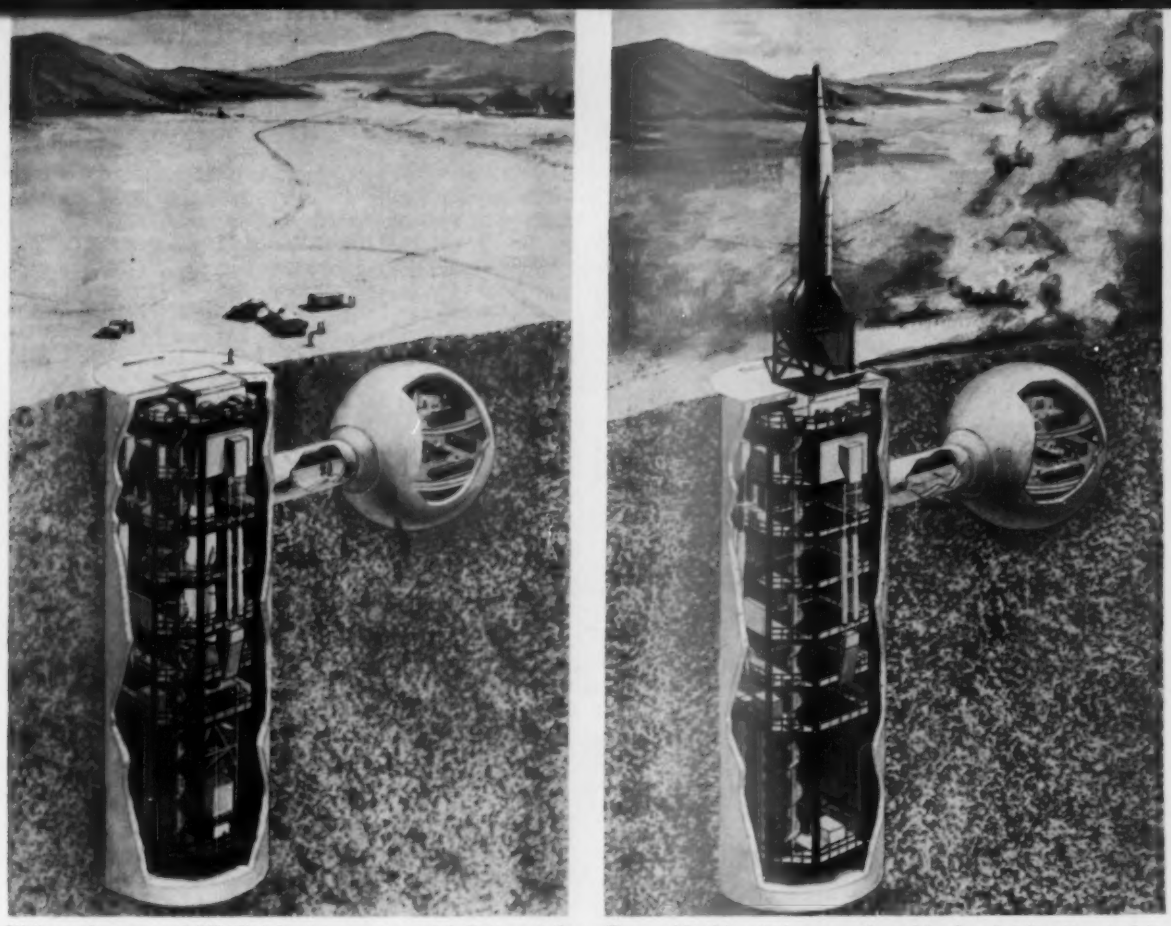
Davis-Monthan AFB	Tucson, Ariz.	2	hard 1x9	18
McConnell AFB	Wichita, Kan.	2	hard 1x9	18
				90

* Operational mid-1961

BOEING MINUTEMAN

Malmstrom AFB	Great Falls, Mont.	3	hard	150

Four more squadrons of Titan IIs have been authorized but locations are not yet announced. Added squadrons probably will not be installed at existing locations.



SILO emplacement of USAF Atlas intercontinental ballistic missiles will resemble this artist's conception of hardened Atlas site. At left, maintenance, checkout and fueling operations are carried out underground. Atlas has been raised at right and its rocket engines ignited. Countdown is conducted in spherical underground blockhouse at the right of silo.

tions, no training shots will be launched because all sites other than Vandenberg will be on alert status and geared to fire only in the event of war.

An additional squadron in a 3 x 3 soft configuration—three clusters of three missiles each grouped around three guidance centers—is under construction at Warren as well as a 1 x 9 dispersed semi-hard all-inertial guidance squadron of Atlas-Es, making a total of 24 missiles located in the Cheyenne area.

SAC's first units at Warren, the 564th, 565th, and 549th Strategic Missile Squadrons, are being pushed toward operational status by Air Force Ballistic Missile Division and Convair field personnel. Scene of this activity is a 92-year old former cavalry post built to protect builders of the transcontinental railway from Indian raids.

First two sites of the 565th SMS in a hybrid 3 x 2 configuration were accepted by BMD and Convair from the Corps of Engineers last July. Work since then has been concentrated on installation of GSE and instrumentation and the checkout of more than two million connections and terminals between blockhouse, guidance center and launching pad. First Atlas missile was trucked to Warren from San Diego last October. Since then, four additional missiles have been placed at Warren. Airlift by Douglas C-133 Cargomaster has replaced truck delivery.

An erroneous report that Warren had become operational circulated last April when three missiles were initially erected at the first site of the 565th squadron. SAC personnel pointed out that the erecting procedure is only part of extensive measures required to check out the ground support equipment and facility before the site becomes operational.

Actual Date

Actual date for the first missile squadron at Warren to become operational is scheduled for mid-1960.

Next squadron to be completed at Warren will be the 564th, with a conventional 3 x 3 arrangement in soft configuration. Work only recently was begun on excavation for the 1 x 9 semi-hardened sites which are dispersed within a radius of 45 mi. of Cheyenne. Scheduled completion date for the entire complex at Warren is in the fall of 1961.

Following the calculation indicating that no single thermonuclear explosion will knock out more than one hardened missile, individually-housed missiles in the 1 x 9 arrangement will be at least 18-20 mi. apart.

Dispersal, however, has caused many problems, the solutions to which have not yet been found. Nearest site to Warren in the 1 x 9 complex will be 15 mi. from the base; the farthest 45 mi. It has been calculated that approximately 700 road miles of travel will be necessary to visit every site in the Warren complex.

A partial solution to the logistic problem is afforded by the use of helicopters for the transportation of small parts and limited numbers of personnel. Warren has received two of four Kaman H-43 Huskies scheduled for this purpose and helicopter landing pads are being readied.

Considerable road travel still will be necessary when the missiles are returned each six months to the Missile Assembly Building for periodic inspections. Maintenance at the 1 x 9 sites will necessitate considerable time on the road by mobile teams, but the 3 x 2 and 3 x 3 sites will not pose so great a problem.

Rotation of personnel at the site and the duration of the alert tour still has

to be established. Distances involved appear to be too great to permit daily rotation, although the remoteness of the sites appears to necessitate a short tour. Severity of Wyoming winters likewise will be a factor in determining crew rotation. It is not unusual for heavy wintertime snows to isolate remote areas for as much as a week and surface logistic transportation may be seriously compromised in the winter months.

Manning requirements establish that a minimum of five crews per missile is needed to permit around the clock readiness. Aside from the still unspecified tour of duty on alert, time will have to be provided for other military duties, transportation to and from the site, leave, sickness, etc.

Opinion seems to be divided regarding the human factors problems involved in continuously manning these remote sites. Experience to date with the 17-man crew at soft sites indicates that boredom is not a problem since the learning curve still is definitely on the rise, and a routine operation has not yet evolved. Perhaps more critical will be the manning problems associated with Atlas-E and Titan in the 1 x 12 and 1 x 9 sites with three-man crews. Only prolonged experience with maintaining the missile on alert status at an operational site will provide the answers to the manifold personnel problems involved and permit the establishment of a regular routine and tour of duty. As the first operational site, Warren undoubtedly will be the test base during the evolution period.

Command Setup

The three squadrons at Warren are under the 706th Strategic Missile Wing, headquartered at Warren, which in turn is under the 13th Air Division, also at Warren. A second strategic missile wing, the 703rd, also is under the 13th Air Division. Two Titan Mark I squadrons at Lowry AFB, Colo., comprise the 703rd Air Division.

Normal communication channels from Strategic Air Command headquarters at Offutt AFB, Neb., go through 15th Air Force Hq., March AFB, Calif., to 13th Air Division at Warren. However, emergency communications exist, allowing SAC headquarters direct communication with 13th A.D. and also directly with each missile site. Backup channels provide for emergency communication in case the Warren war room, located in the unprotected missile assembly building, is damaged. Similar provisions are in effect at Vandenberg and at all other ICBM bases under construction.

At other bases throughout the U.S., nine more strategic missile squadrons are under construction, including one soft squadron, two semi-hard squadrons and six squadrons deployed in 1 x 12 hardened sites, making an eventual total of 123 Atlas missiles on 15-min. alert, plus those which Vandenberg may muster in an emergency.

Construction also is under way at seven different locations in the western U.S. for installation of nine squadrons of the Martin Titan ICBM in hardened sites.

Scheduled to be phased into SAC's missile inventory about mid-1961 is the first operational Titan I squadron at Lowry AFB, Colo. A total of six Titan I squadrons in 3 x 3 hard configuration are scheduled at five different locations in the western U.S. Each of the Titan Is will be clustered because of the requirement for a guidance center for the radio-inertial system.

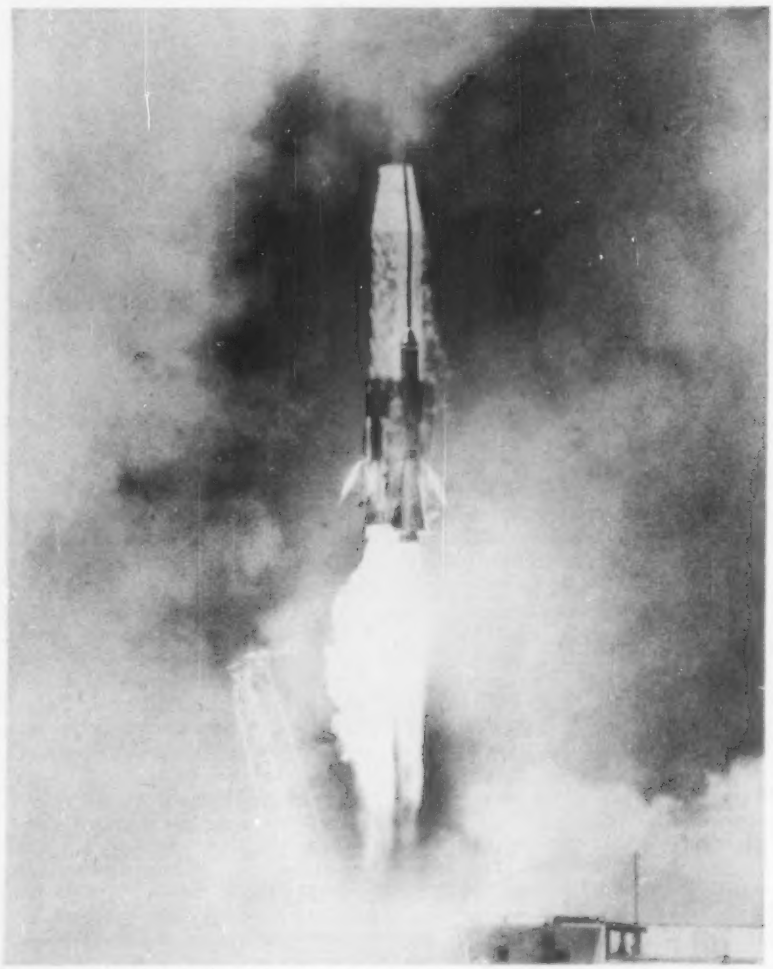
Four Titan II squadrons, in hardened 1 x 9 sites, featuring all-inertial guidance and storable propellants with in-silo launch capability, are scheduled at two different locations. An additional four squadrons of Titan IIs have been authorized, but the locations have not been announced.

Martin Co. said that sites for Titan will be opened in rapid succession following the initial operational site at Denver, since work at all sites is proceeding concurrently.

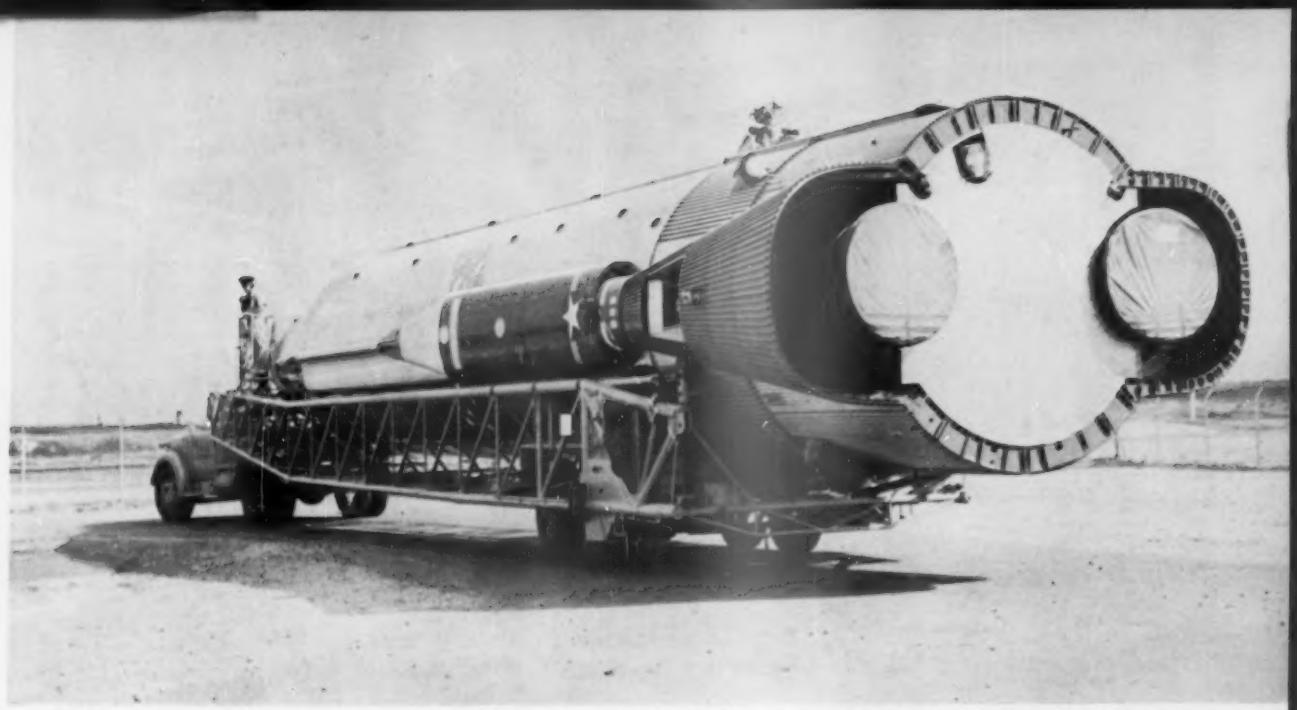
Operational Firing

First operational firing of a Titan I is anticipated at Vandenberg in the fall of this year. The first missile arrived last March and presently is in the Guided Missile Assembly Building awaiting completion of the first silo. This first Titan silo will be of the hardened 3 x 3 configuration being installed at the first five locations, and will provide for raising the missile and its submerged guidance antenna to the surface prior to firing. Excluding the Titan silos at Vandenberg, a total of 10 Titan squadrons are planned in 1 x 9 deployment.

Contracts also have been let on the first Minuteman squadron located in the vicinity of Malmstrom AFB near Great Falls, Mont. Mobility concept for Min-



FIRST Atlas launched by a Vandenberg AFB-trained crew from Warren AFB, Wyo., rose from its semi-hardened launching pad Apr. 22, 1960. Shot was the first from a horizontal storage pad and the second ICBM to be launched from Vandenberg in 1960.



VISIBLE at top of Atlas intercontinental ballistic missile, being hauled by truck trailer to Vandenberg AFB missile assembly building, is one of two small vernier engines which trim missile's velocity when it has reached approximately 15,000 mph. After verniers are shut down, nose cone separates and arcs downward in a true ballistic curve.

uteman calls for three to five missiles to be carried by train and deployed on 900 to 1,500 mi. of railroad track. Precomputed launch points will be designated along the rail lines and the trains shifted in a random pattern to preclude the possibility of the missiles being marked for initial destruction.

First SAC missile train tests will begin this month with a series of six deployments of 14-car simulated missile trains of seven to 14 days each through the far west, northwest and midwest. SAC has organized a special task force and control center for mobile Minuteman operations at Hill AFB, Ogden, Utah commanded by Col. Virgil M. Cloyd, Jr., who previously was director of operations for the First Missile Division.

Test Train

Test train will be manned by a military crew of 21 SAC personnel, most of them specialists in transportation, communications and diesel power. American Association of Railroads will also have coordinating personnel abroad.

Train includes a command and control car equipped with single side band and UHF radio for contact with the Ogden train control center and SAC headquarters (see p. 168).

No missiles will be carried in these initial tests.

Construction of Atlas sites plus installation and checkout of ground support equipment is under the direction of AFBMD and Convair-Astronautics Division of General Dynamics Corp. Convair's contract is with AFBMD through the Ballistic Missile Center, which functions as an adjunct of the Air Materiel Command.

BMD has the executive management responsibility for delivering to SAC a complete weapon system in final operational form. To accomplish this, BMD is charged with the complete technical direction, systems engineering, technical facilities design, programing, budgeting and implementing management responsibility to create, develop, test and deploy the ICBM weapon system in its operational environment.

Construction Cost

Cost of construction, which is administered by the Army Corps of Engineers, is in excess of $480 million for Fiscal 1960, three-fourths of the total Air Force construction budget. It will involve from $6 to $8 billion for the total ICBM program.

Corps of Engineers' role extends only through the so-called "brick and mortar" phase of the work which calls for delivering to BMD a site ready for installation of ground support equipment.

After contractors under Corps of Engineers finish their work, BMD and Convair then start installation of operational equipment and run checkout procedures. Despite much careful planning, difficulty often is encountered with the area of mating between the facility and the weapon system GSE. Considerable easing of these problems is expected as more sites are prepared, since one of the big headaches in the day to day task is cataloging and recording problem areas for feed back to other BMD and Convair field offices. As experience is gained, modifications are incorporated into other sites as they are built, effecting considerable time saving.

NORTHROP SNARK missile for Strategic Air Command gets last minute check on its launcher at Presque Isle AFB, Me. Intercontinental missile has 5,500 mi. range.

FIRST Atlas E intercontinental ballistic missile is installed at Warren AFB, Wyo. at No. 1 launch site in 3 x 2 soft configuration.

SAC Cuts ICBM Crews, Maintenance

One of the biggest lessons learned in initial ICBM operations was the attractive possibilities for reducing the personnel required for both launch control crews and maintenance. Initial soft-site, gantry rigged operational Atlas at Vandenberg AFB utilized a 17-man combined launch and maintenance crew. Consideration is being given reduction to five-man launch control crews for the "coffin" sited Atlas using radio-inertial guidance. Launch control officers are generally in the first and second lieutenant ranks, with occasional captains, and are carefully selected. Many of the new SAC operational missile units are drawing their launch control officers from USAF portions of the West Point and Annapolis graduating classes.

Five-man launch control crew would consist of:

- **Launch control officer,** who conducts the final 65-sec. countdown sequence and is the only man who can, on command from SAC, launch the missile.
- **Guidance control officer,** who is responsible for checking and operating the guidance system in the combination radio-inertial systems. With the all-inertial guidance squadrons this job is eliminated. These usually are lieutenants.
- **Missile system analyst.** This is an airman rating who operates the automatic checkout equipment for the missile systems preparatory to entering final countdown.
- **Missile maintenance technician.** This is also an airman who does minor maintenance including replacement of defective subsystems pinpointed by automatic checkout routines.
- **Powerplant producer.** This is another airman who operates all of the auxiliary power systems required in handling the missile during prelaunch operations.

One of the major lessons learned from early operational training is the elimination of static firings on the launch pads. Experience has indicated that all the really essential training can be accomplished by complete double propellant (liquid oxygen and RP-4 kerosene based fuel) drills and that actual engine ignition adds little to a crew's combat capability.

Missile Reliability

A major answer to missile reliability is still being sought at Vandenberg in tests to determine how long an ICBM can sit combat ready on its launch pad or inside its silo and still remain capable of actual launching. Exercises are now being planned at Vandenberg to take missiles that have been on their launching pads at intervals of three and six months and a year, substitute training warheads and a Wake Island bullseye guidance tray and then order their crews to a "no-notice" combat firing similar to the Reflex mission alerts for bomber crews. From this type of operation SAC hopes to develop accurate data on missile reliability during long periods of combat ready alert, with the exception that fuel tanks remain dry.

The readiness test will simulate as closely as possible conditions at other operational sites and will afford SAC data on whether or not the procedures and techniques evolved so far are placing them on the proper track.

Since the theory of SAC's retaliatory force is one of instant readiness, any equipment or personnel not available for immediate action might well be lost to future action and cannot be counted on to provide a part of the deterrent capability. A much greater strain, therefore, is placed upon those responsible for maintaining ICBMs than upon those responsible for keeping aircraft in commission.

Aircraft maintenance largely is predicated on the theory that anywhere from 10 to 25% of the force can be inoperative at any one time for scheduled and unscheduled maintenance. With missiles, due to the limited number of launching sites available and the requirement for 15-min. readiness, an in-commission rate approaching 100% is required. A strain, therefore, is exerted on maintenance personnel and supply pipelines which necessarily forces a compromise between in-commission time, inspection requirements and modification procedures.

Early in the ICBM program, an effort was made by Convair and the Air Force to establish the number of items in the weapon system needing periodic inspection. A total of 10,474 inspection items were established as the initial requirement. It soon became obvious, however, that this workload, coupled with the requirement for frequent calibration of various components in the missile system, would render it impossible ever to have the missile ready for launching. SAC and BMD, together with Convair, have succeeded in paring down inspection items to 3,010.

Calibration of the many pressure and temperature sensing devices within the missile system and within its ground support equipment also imposes a very heavy workload on maintenance. SAC personnel are frank to admit that they failed to recognize the magnitude of the calibration requirement in the early stages of establishing maintenance requirements. Calibration is doubly important because of the lack of alternate or backup systems in a missile such as are available in aircraft and because of the lack of a crew which, in effect, calibrates many aircraft instruments by visual check.

Calibration of valves, switches, pressure sensors, etc., presented so great a demand on maintenance technicians that action was taken to reduce the requirement. As a result of careful scrutiny, requirements for calibration have been reduced by 40%.

A parallel might exist between aircraft and missile maintenance if the operating crew of the aircraft performed all daily, preflight, postflight, intermediate inspections and minor technical order compliance modifications. Missile maintenance procedure, as now evolved by SAC for Atlas, is performed in that manner.

In the case of Atlas-D with radio-inertial guidance in the 3 x 3 configuration, the 13-man launch crew and 4-man guidance crew performs all inspections and tech order compliances on the missile to which they are assigned at the site. After 180 calendar days, the missile is removed from the site and returned to the Missile Assembly Building (MAB) where it undergoes a complete disassembly, inspection and any repair that is necessary. Six-month periodic checks now take six weeks and are conducted by an all-Air Force crew at Vandenberg. Spare missiles are kept in the MAB so that the site is off alert status for only the short time necessary to effect removal of one missile and installation of another.

Maintenance procedures will change in the case of the all-inertially guided Atlas-E in dispersed 1 x 9 sites because of simplified propellant loading procedures and elimination of the guidance center. Missile crews, in the case of the E series, will be comprised of four men, through elimination of the guidance officer.

Mobile teams of trained maintenance technicians will be dispatched to dispersed sites as roving specialists to perform regularly scheduled maintenance. The launch crew will be charged with conducting daily inspections and will report malfunctions to a central maintenance control office. A maintenance team also can be sent to a site to accomplish repairs or unscheduled maintenance.

In order to support a nearly 100% in-commission rate, a radical new supply procedure has been initiated. Main theory behind the revamped supply procedure is the almost complete elimination of paperwork on the part of both the using organization and the Air Force weapons supply organization (AFW). Vandenberg's supply operates on a 24-hr. day, seven-day week with personnel available to locate and deliver parts to the user. The log of incoming calls and outgoing delivered parts showed that at 1:25 a.m. a call came from site 576B for a part resulting in an MOCP (Missile Out of Commission for Parts). Quick reference to a cross index file showed that the part was available in stock and it was quickly located. The part was dispatched by pickup truck to the site, arriving at 1:55 a.m., 30 min. after the call had been received. At no time was it necessary for the requesting agency or for AFW to execute any paperwork to effect requisition of this part.

Stock Control

Control of the stock level at AFW supply is assured when an operator fills out an IBM punch card to record the operation. The information recorded on the punched cards is transmitted by data transceiver to the Atlas prime depot at San Bernardino Air Materiel Area, headquartered at Norton AFB, Calif.

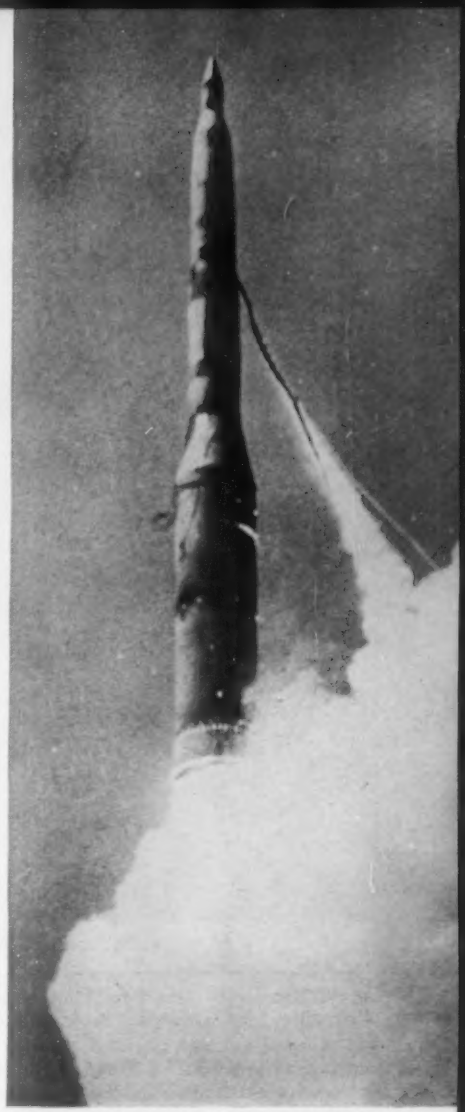
Information from the punched cards then is recorded on identical cards at Norton and fed into an IBM 705 computer. The computer automatically records the transaction, queries its memory system to determine the stock level of the particular part at the depot and issues a requisition for a like article to be shipped to Vandenberg. Should the IBM memory show the stock level at the depot to be below a specified level, the computer automatically issues a requisition to the prime or subcontractor for a like item to be placed in stock at SBAMA.

Same procedures apply to High-Value items which, because of cost are stocked only in limited amounts. These are requisitioned from the manufacturer and airlifted to Vandenberg. AFW supply officers at Vandenberg report that most High-Value items requisitioned for operational sites are delivered within 24 hr., very often within 12 hr., providing they are located within the Southern California area. Commercial carrier airlift is used. Similar supply and requisition procedures are being instituted at all missile bases within the U.S. as they become equipped with missiles.

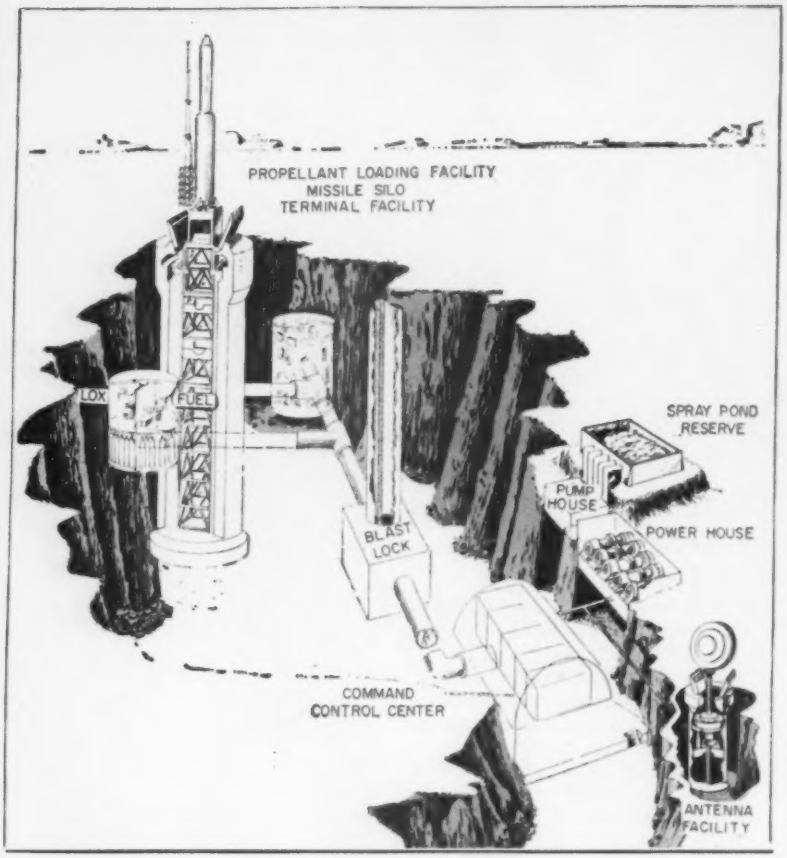
Success of the streamlined supply system, however, depends on having the proper amount and type of spares on hand and this is the major cause of headaches in the new procedure. Main difficulty is a lack of experience in operating and maintaining missiles. Early conferences between Air Force and contractors sought to determine the frequency of replacement of various components and parts.

The unique one-time use and limited lifespan of the vehicle, coupled with the complexity of missile systems, made the task extremely difficult. Result is that even with the Thor missile, already operational, only limited knowledge is available to establish an adequate spares stock. Undoubtedly, as the missile remains on station and as time progresses, the spares stock will seek a more realistic level.

Lessons from Thor, however, have been applied to establishing Atlas spares although only a very small num-



FULL SCALE, flight-weight silo test model of USAF Minuteman intercontinental ballistic missile was fired successfully from its underground silo launcher Sept. 15, 1959, at Edwards AFB, Calif. Heavy nylon cable attached to the missiles in test series launches restricts their flight to a few hundred yards.



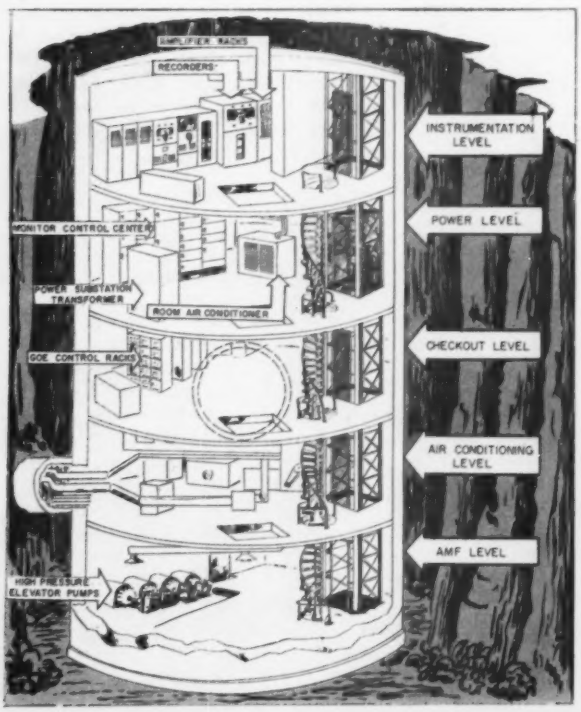
ARTIST'S concept of the Titan ICBM complex similar to one now being completed at Vandenberg AFB, shows the Titan I with radio inertial guidance and above-ground launching. Titan II will have all-inertial guidance and in-silo launch capability. Below (left) are series of support units for Titan, all underground, which include power stations, instrumentation rooms and a checkout level (circle denotes passageway). Fuel and gas storage system is at right. Both areas will be evacuated by crews prior to a firing.

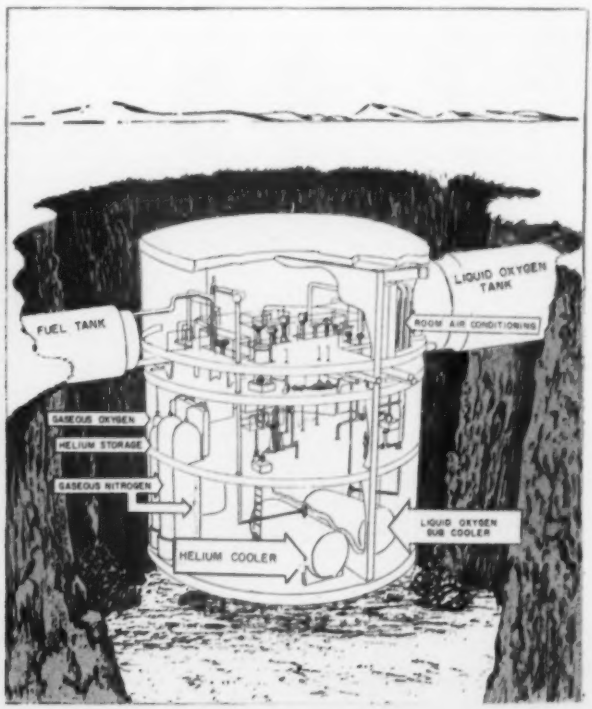
ber of items prove common to both missile systems.

SAC's supply procedure now embodies the following new concepts:

- **Centralized knowledge** of assets in the form of the IBM 705 computer at SBAMA and its extensive memory system.
- **Automatic data processing** done by the IBM 705 and a punch card transceiver located at each base.
- **Automatic supply** which provides for restocking AFW supply as well as depot supply upon computer instructions.
- **Minimum administration** which has seen the almost complete elimination of paperwork in the cumbersome requisition system.
- **Rapid communication** in the form of telephone requests for parts from user to supply and the transmission of punched card data to SBAMA via the IBM data transceiver system.
- **Air transport** to speed all parts from the prime contractor's manufacturing facility or from depot to using organization.
- **Source to user** expediting system wherein supplies are taken directly to the individual performing the actual maintenance at the missile site.
- **Maximum maintenance** at squadron level, which assures a minimum of transit time between the MAB and the missile site.

Both the new concept in supply and the simplified maintenance procedures are aimed at furthering the SAC's operator-maintainer concept. Similarly, the goal is to assure a greater percentage of "in-commission time" through minimum inspection at maximum interval.





CONVAIR B-58 Hustler will add supersonic dash capability to Strategic Air Command's manned bomber force.

SAC Molds Tactics for Bomber-Missile Mix

Strategic Air Command's bomber force is in transition from the conventional subsonic jet vehicles to a more technically advanced and versatile strike force that can attack at supersonic speed and vary its tactics with air-launched missiles, electronic countermeasures and increased ranges.

Both technical development and new tactics are being employed to maintain SAC bombers as an effective fighting force that can survive initial enemy attack, penetrate enemy defenses and deliver nuclear bombs in significant numbers during the initial period of the missile gap.

SAC is getting supersonic capability with the Convair B-58 medium bomber, which is now becoming combat ready, and the penetration capability of the Boeing B-52 is being improved with the addition of penetration and decoy missiles. SAC is dispersing its forces and sharpening reaction time so that now a third of the force can get off the ground in 15 min. Key tactic will be the continuous airborne alert for a significant portion of the B-52 striking force.

Beyond the missile gap period, SAC wants new bombers developed to maintain a modern manned attack force as the most flexible element of the future missile-bomber mix. As the missile force grows and the bomber force declines in numbers, the total SAC mix will reach a balance of roughly half of each within five years. At that point, the role of manned aircraft will be evaluated for the period in which large numbers of Minuteman and Polaris missiles are dispersed to form the backbone of the deterrent. New supersonic bombers such as the B-70, nuclear-powered aircraft and manned space vehicles are the future prospects for this role.

Manned Aircraft Capabilities

Whatever the decision then, SAC does not expect to be able to eliminate manned aircraft completely from its force. They offer a number of permanent advantages over missile delivery systems, including the ability to carry larger nuclear bomb loads and to deliver bombs to more than one target on a single mission. Addition of air-launched missile extends this capability.

Manned aircraft can be sent on missions which require armed reconnaissance to locate and strike targets on the same flight. Human observation and judgment can be used to spot unknown or mobile targets against which a ballistic missile, with its requirement for a known target, cannot be fired. Unlike the missile, the bomber's mission can be changed while it is on its way, and the bomber can do a more accurate job of striking a target precisely. Bomber accuracy is measured in feet while ICBM accuracy is measured in miles.

Unlike the one-shot missile, the manned aircraft can be recovered after a mission and reloaded for another strike. Another advantage is that the bomber carries nuclear weapons which have been demonstrated in action or in tests, while missile warheads have yet to be proven except in theory.

Additionally, because of their weight-carrying capability SAC bombers can carry varied types and mixes of bombs to meet the requirements posed for any degree of destruction to enemy targets in limited or general conflict. This mix includes the entire spectrum of airborne weapons from the heaviest multi-megaton bombs to conventional explosives.

Probably the most effective virtue of

the manned bomber in the cold war era is the capability to launch it toward the enemy with the ability to recall it. SAC's bombers can be ordered out on strike missions on the suspicion of enemy attack with the knowledge that they will not fly beyond a specific point without further positive and specific orders to attack. This provides time to analyze a threat and decide whether it is real or a false alarm. This is not possible with the ballistic missile, which irrevocably commits a nation to war once it is fired.

Warning Problem

Warning is the key problem for SAC in its retaliatory role. As the Soviet threat shifts from manned bombers to ballistic missiles, warning time is drastically reduced. SAC's problem is to make sure it can get enough bombers off in an attack to deliver a significant retaliatory blow. A variety of tactics have been developed to keep the bomber force effective during the missile gap years, which probably will extend close to 1965.

Key tactic in the missile gap period will be the airborne alert in which a part of the B-52 force is in the air all the time, safe from surprise attack and ready to turn toward enemy targets.

Airborne Alert

Lacking the certainty of reliable warning of enemy missile attack during the coming few years of missile gap, SAC wants to operate an airborne alert as insurance that at least part of the bomber force would survive any surprise attack. Under this concept, part of the B-52 force would be airborne at all times, flying patterns over northern areas which would keep each bomber within striking distance of its target 90% of the time in each 24 hr. pattern. Tankers would supply the fuel to keep the relays of B-52s in the air. These missions would be flown out of range of the Soviet radar screen and over friendly territory or international waters.

SAC wants to keep a quarter of the B-52s in the air at all times. This was proposed to the Air Force in March, 1959, and the idea was reviewed by the Joint Chiefs of Staff and the Defense Secretary. The decision was reached last fall to scale down the SAC concept to a relatively modest program of buying enough engines and other spare parts to maintain an on-the-shelf capability to operate an airborne alert with one eighth of the B-52 force for one year.

This capability would be held in reserve for an emergency.

Alert Plan

Defense Department on-the-shelf plan provides the money for spares and for some crew training in air alert techniques. Since there is no DOD-approved plan now to start operating an air alert once the capability is attained, no provision has been made for extra crews or for extra fuel.

Under the SAC plan, a quarter of the B-52 force would be able to go into the air and stay there on a rotational basis as soon as the spares capability could be attained. This type of operation would quadruple presently scheduled B-52 flying hours, with a corresponding requirement for extra spares. It would also require an increase in the ratio of crews to aircraft from 1.6 to 2.

With either plan, no airborne alert will be possible until early next year because of the lead time involved in crew training and in building up a stockpile of spares. Defense Department released initial funds last December to begin stockpiling spares for one eighth of the B-52 force, but a larger spares program would be required for the constant alert SAC wants. Lead time cannot be compressed much, and any decision to go ahead with a constant air alert program would have to wait out the lead time before it can be implemented.

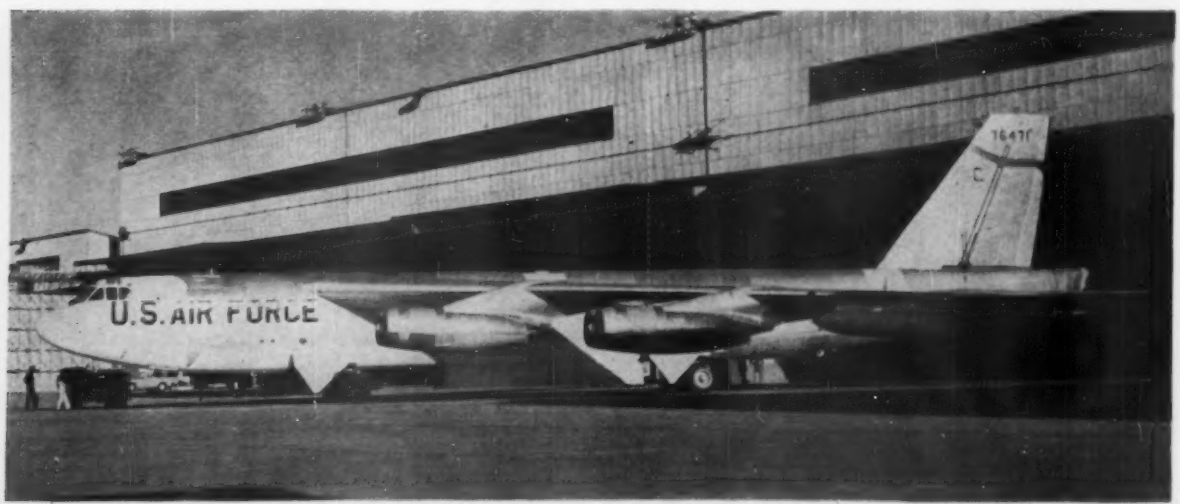
SAC has tested the air alert concept over a two year period and found it feasible. Readiness training is now under way. These training exercises have been erroneously described as a kind of small airborne alert already in being, but they are strictly training and don't provide the strike capability inherent in the true operational concept.

Budget Allotment

Defense Department allotted $85 million for buying spares and $15 million for alert training in the Fiscal 1960 budget and $60 million and $25 million respectively for these purposes in the Fiscal 1961 budget. This includes provision for a Boeing KC-135 alert force. Annual cost of actually flying an alert with the capability to be provided for one eighth of the B-52 force would run $225 million in addition to present B-52 and KC-135 operating costs.

For the kind of airborne alert SAC wants to operate, $492 million would have to be added to the original Fiscal 1961 budget request. This would cover more spares, plus extra crews and the money to train them. Once the capability were attained for a quarter of the B-52s, it would cost an estimated $800 million a year in addition to presently scheduled B-52 and KC-135 funds to operate it. This would be largely for fuel and spares required to keep the shelf full.

Congress has given President Eisenhower the authority to incur a deficiency in USAF funds to implement a



BOEING B-52G, modified for Pratt & Whitney TF33 turbofan engines which will be fitted on the B-52H, rolls out at Wichita.

NORTH AMERICAN Hound Dog missile carried on wings of a Boeing B-52G serve as a penetration weapon.

continuous airborne alert any time he feels it is justified. Under this authority, the Defense Department can spend the required money immediately, then go to Congress later for an appropriation to make up the deficiency.

Under the ground alert concept, a third of SAC's bombers stand ready with their tankers to take off within 15 min. The aircraft stand in special areas at the command's bases, armed and fueled. They have been run through the preflight check up to the point of starting engines, so all the crews must do is start engines and taxi to the runway. This preflight is repeated daily during the seven day alert period to make sure the tankers and bombers are ready in their "cocked configuration."

Aircraft Ready

At some bases bombers sit "cocked" in special areas patterned on the basis SAC "Christmas tree" complex. In this pattern, they are parked on ramp strips which angle into a central taxiway much as the limbs of a tree are attached to its trunk. This facilitates a fast exit from the alert area to the runway. Generally there is a building adjacent to this aircraft complex in which the crews live while on duty. The whole area is enclosed by a security fence.

Alert crews live together in these buildings, or in trailers set close to their aircraft, all through their week of duty. Tanker crews live under the same conditions as bomber crews. Ground crews also are maintained on 24 hr. alert duty, although this is split into three separate shifts. These ground crews run hourly checks and moves aircraft wheels periodically to avoid flat spots. They have top priority on parts and technical support from their base. Any aircraft not ready to go is removed and replaced.

About a week before they go on duty, alert crews enter a security area to study target folders covering the combat missions they will be assigned. They must spend seven hours studying the new target systems, since their alert duty targets differ from the normal targets assigned them. They also must remain current on target information and procedures, which change constantly.

In some cases crews can leave the alert complex for such places as the base chapel or officers club as long as they stay together and travel along specified routes. SAC tries to make good use of the time spent on alert duty by planning a full schedule of ground training. When they leave alert status, crews go back into the regular training and operational cycle which calls for an evarage of 32 flying hours a month.

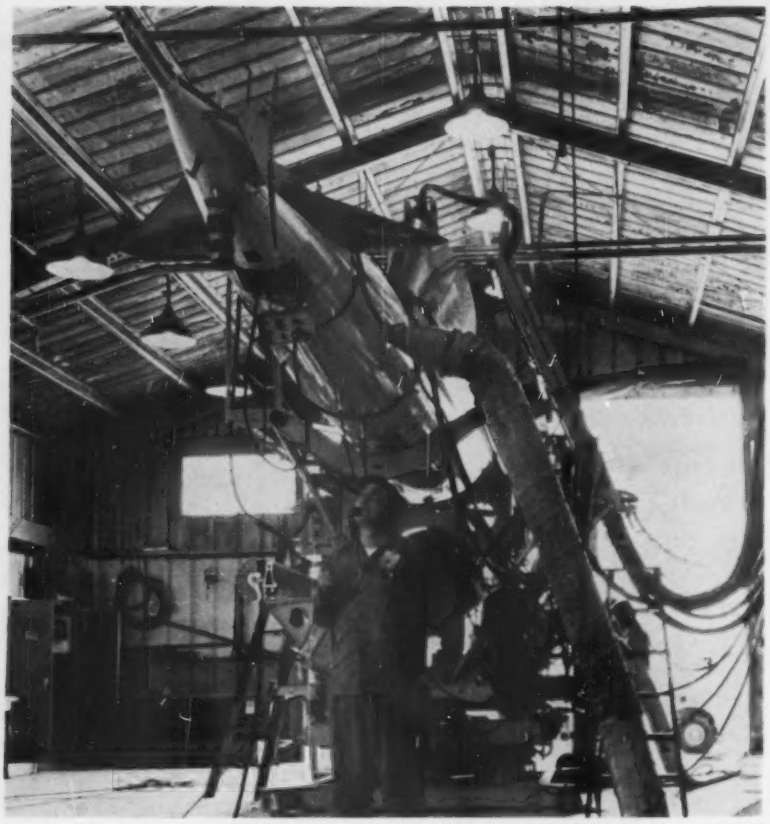
Test alerts are called at random points during the alert period to test crew and aircraft reaction times. The alarm sends crews to their aircraft where they prepare for takeoff until the test is called off. Sometimes it is halted before engines are started, other times the engines are started and the aircraft taxied to the runway for takeoff before the test is terminated.

Alert aircraft are replaced and flown at the end of the week. This avoids maintenance problems that arise with static aircraft, and it demonstrates that the aircraft were ready to fly at the end of their seven days of readiness.

Ground Alert

All overseas forces are part of the ground alert. SAC has replaced its past practice of rotating B-47 units overseas on a 90 day basis with a new concept, called Reflex, in which crews and aircraft spend no more than three weeks at foreign bases. All B-47s are based in the U.S., and they are rotated to bases in North Africa, Spain, United Kingdom, Alaska and Guam on an average 21 day cycle. Crews fly their aircraft to a forward base and go on alert for a week. Then an alternate crew replaces them for several days while they rest or travel. They stand a second week of alert before returning home.

Reflex is aimed at maintaining a constant ground alert at forward bases on a rotational basis. Crews seem to prefer it to serving their alert time at home bases with the distractions of nearby families. It saves USAF money because



FUNCTION of forward elevators of a GAM-77 Hound Dog missile is observed by USAF sergeant during combined systems check, in which missile is put through all flight positions.

the B-47s are not overseas long enough to require any major maintenance, and a relatively small maintenance forces are kept at foreign bases on a 60 day rotational basis.

With the introduction of the long range B-52, SAC has been able to withdraw gradually from its network of overseas bases and concentrate the bulk of its operations in the continental United States. Some overseas operations are maintained for Reflexed B-47s and as recovery points for crippled SAC aircraft, but the trend has been toward the use of U. S. bases as the role of the B-47, which requires overseas bases, slowly diminishes. This is cheaper and offers fewer logistics problems, and it avoids some of the diplomatic problems that have plagued operations overseas.

Dispersal Program

As the bomber force stationed in the U. S. has grown, SAC has been building new bases to disperse this force. The goal has been to have no more than one B-52 squadron with its associated tanker force on each base. SAC has added 26 new heavy bomber bases to the 11 bases built for the B-36, and further dispersal is accomplished by stationing strategic wings of B-52s as tenants on bases run by Air Materiel Command, Tactical Air Command and other Air Force elements. Generally, SAC has located its new bases in the northern part of the country to cut flight time to the polar areas bombers will cross on their attack missions.

Strategic wing includes 15 B-52s and 10 KC-135 tankers. Farming these strategic wings out as tenants helps meet SAC's goal of operating no more than one B-52 squadron of 15 aircraft at any base. Usually some maintenance facility construction is necessary to prepare a tenant base .o handle the B-52.

B-47 fleet is now being given additional dispersal capability, in addition to Reflex, through a training and familiarization program that will enable small B-47 detachments to use civil airfields for short periods of operation. This B-47 periodic dispersal pattern will utilize civil airports where runways, parking areas and other facilities for short periods of operation already exist. This random dispersion of portions of the B-47 fleet will further complicate any enemy surprise attack problem and also cycle into re-use of the tanker fleet employed in the airborne.

As the B-47 is phased down, SAC may combine its remaining medium bombers into wings larger than the present 45 aircraft. This would save manpower and release bases for the B-52 and the B-58. The command is experimenting with two 70 aircraft wings now at Plattsburgh and Hunter AFBs.

Dispersal accomplishes three goals. It provides more runways and thereby permits SAC to get more aircraft off the ground in a given time. It makes it more difficult for the enemy to destroy all of the bomber force on the ground by providing a larger number of targets. And by providing all these necessary targets, it increases the size of the attack force an enemy must use. These factors decrease the prospect of a successful surprise attack and thus increase the deterrent value of the bomber force.

Along with providing more runways, SAC is developing techniques for getting aircraft into the air at shorter intervals. Last January, SAC completed a series of test under the Open Road project in which B-47 takeoff intervals were reduced from one minute to 15 sec. It had been assumed previously that exhaust smoke and turbulence left by a heavy aircraft must be allowed to clear before another could take off. Tests at Edwards AFB indicated that crews have little trouble with smoke or turbulence in close interval takeoffs.

With this technique, crews complete preflight checks while taxiing, then apply full power and take off as soon as they reach the end of the runway. They use two white lines painted on the runway for guidance, alternating between them in the takeoff sequence. Early test were conducted with B-47s in which more than 500 Jato bottles were fired without a failure, and in an April test SAC got six KC-97s off in 59 sec. Five B-52s have taken off within 1 min. 8 sec. Testing period is over, and SAC is now in the training phase with this concept.

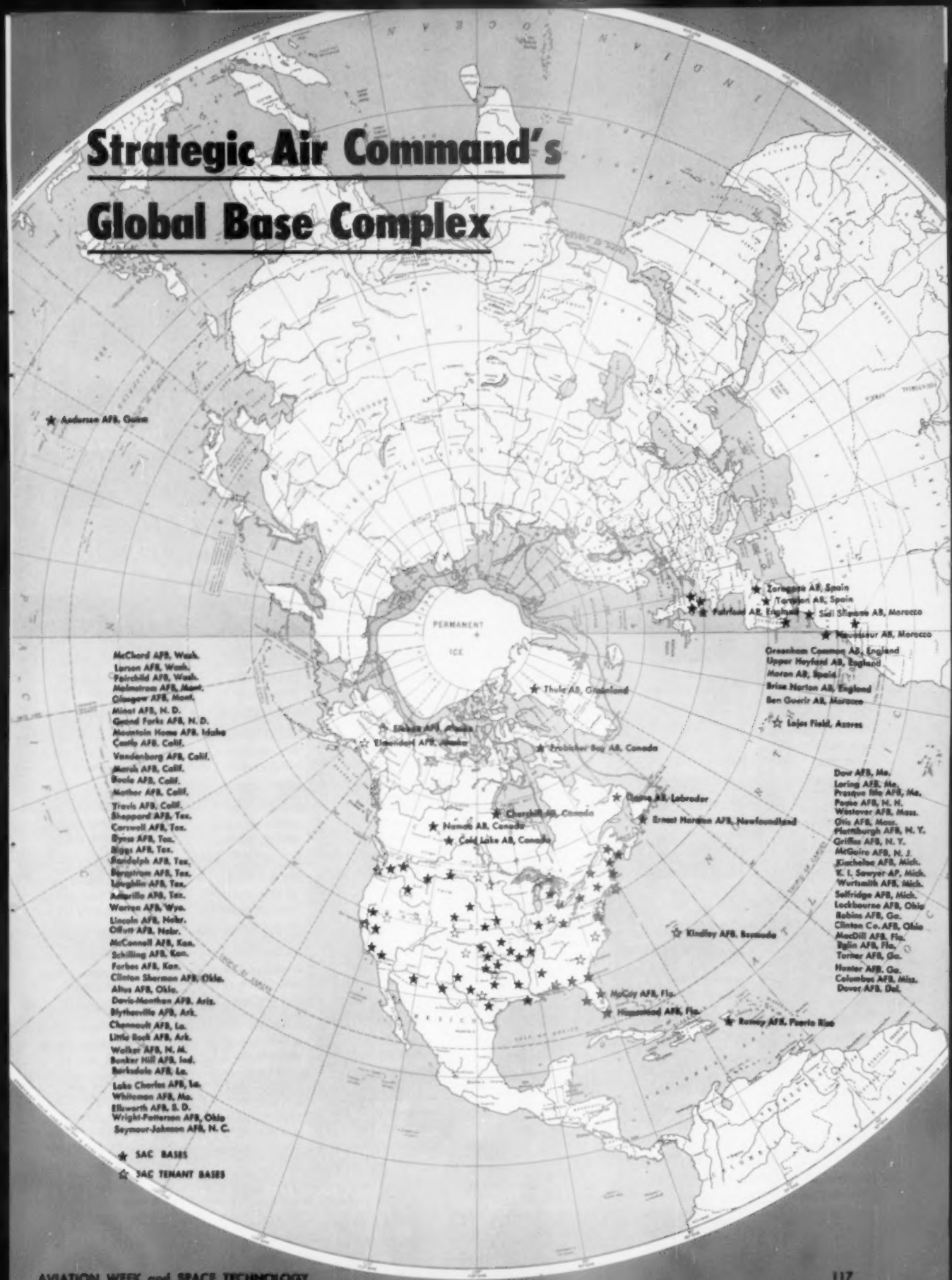
SAC Force

The bulk of the SAC force currently is composed of B-47s, but these obsolescent medium bombers and the piston-engine Boeing KC-97 tankers are being phased out. First B-47 was delivered in 1951, and SAC built a force of about 1,800 of them before it began to phase them down to the present level of about 1,400.

As the B-47 force declines, the B-52 force is still growing. Although the bulk of the 744 B-52s in the present procurement plan have been delivered, new models are still coming into the inventory, and, with the aid of such weapons as Hound Dog and Skybolt, the life of this heavy bomber is expected to extend beyond the mid-sixties.

First squadron of supersonic B-58s is now in transition training. This medium bomber will fill the role performed by the B-47, although it will not be deployed overseas under current plans. The B-58 is scheduled for limited production, but this program has not yet been finalized.

Strategic Air Command's Global Base Complex



STRATEGIC AIR COMMAND

General Thomas S. Power Commander in Chief

Lt. Gen. Francis H. Griswold
Vice Commander in Chief

Maj. Gen. W. H. Blanchard
Director of Operations

Major Gen. W. K. Martin
Director of Personnel

Maj. Gen. E B. Broadhurst
Chief of Staff

Brig. Gen. R. N. Smith
Director of Intelligence

Colonel G. S. Wilson
Staff Chaplain

SECOND AIR FORCE
HQ Barksdale AFB, La.
Lt. Gen. John P. McConnell, Commander

- 4th Air Division, Barksdale AFB, La.
- 816th Air Division, Altus AFB, Okla.
- 19th Air Division, Carswell AFB, Tex.
- 42d Air Division, McConnell AFB, Kan.
- 4321st Strategic Wing, Offutt AFB, Nebr.
- 806th Air Division, Chennault AFB, La.
- 21st Air Division, Forbes AFB, Kan.
- 40th Air Division, Wurtsmith AFB, Mich.

- 22d Air Division, Clinton County AFB, Ohio
- 17th Air Division, Whiteman AFB, Mo.
- 825th Air Division, Little Rock AFB, Ark.
- 818th Air Division, Lincoln AFB, Nebr.
- 4228th Strategic Wing (H), Columbus AFB, Miss.
- 4042d Strategic Wing (H), K. I. Sawyer Airport, Mich.
- 4123d Strategic Wing (H), Clinton-Sherman AFB, Okla.
- 4045th Air Refueling Wg., Selfridge AFB, Mich.

- 4043d Strategic Wing (H), Wright-Patterson AFB, Ohio
- 97th Bombardment Wing (H), Blytheville AFB, Ark.
- 4239th Strategic Wing (H), Kinchelae AFB, Mich.
- 4245th Strategic Wing (H), Sheppard AFB, Tex.
- 4130th Strategic Wing (H), Bergstrom AFB, Tex.
- 305th Bombardment Wing (M), Bunker Hill AFB, Ind.
- 4397th Air Refueling Wg. (Tng.), Randolph AFB, Tex.
- 4080th Strat. Reconnaissance Wg. (L), Laughlin AFB, Tex.

EIGHTH AIR FORCE
HQ Westover AFB, Mass.
Lt. Gen. Walter C. Sweeney, Jr., Commander

- 45th Air Division, Loring AFB, Maine
- 57th Air Division, Westover AFB, Mass.
- 817th Air Division, Pease AFB, N. H.
- 820th Air Division, Plattsburgh AFB, N. Y.
- 801st Air Division, Lockbourne AFB, Ohio
- 823d Air Division, Homestead AFB, Fla.
- 6th Air Division, MacDill AFB, Fla.
- 303d Air Refueling Sqdn., Kindley AFB, Bermuda

- 822d Air Division, Turner AFB, Ga.
- 4084th Air Base Group, Sondrestrom AFB, Greenland
- 4082d Strategic Wing, Goose AB, Labrador
- 4083d Air Base Wing, Thule AB, Greenland
- 4137th Strategic Wing (H), Robins AFB, Ga.
- 321st Bombardment Wing (M), McCoy AFB, Fla.
- 4039th Strategic Wing (H), Griffiss AFB, N. Y.
- 702d Strat. Missile Wg. (Snark), Presque Isle AFB, Maine

- 4081st Strategic Wing, Ernest Harmon AFB, Nfld.
- 4038th Strategic Wing (H), Dow AFB, Maine
- 305th Air Refueling Sqdn., McGuire AFB, N. J.
- 4241st Strategic Wing (H), Seymour-Johnson AFB, N. C.
- 2d Bombardment Wing (M), Hunter AFB, Ga.
- 4135th Strategic Wing (H), Eglin AFB, Fla.
- 72d Bombardment Wing (H), Ramey AFB, Puerto Rico

Major Gen. J. D. Ryan
Director of Materiel

Brig. Gen. S. J. McKee
Director of Plans

Brig. General J. B. Knapp
Director of Civil Engineering

Brig. General J. W. Wilson
Inspector General

Brig. Gen. T. C. Bedwell Jr.
Command Surgeon

Colonel A. P. Pearl
Director of Comptroller

Colonel D. C. Foster
Director of Information

Colonel R. R. Dickey Jr.
Staff Judge Advocate

Colonel John F. Batjer
Asst. CinC SAC

Colonel Byron K. Enyart
Director of Administrative Services

FIFTEENTH AIR FORCE
HQ March AFB, Calif.

Lt. Gen. Archie J. Old, Jr., Commander

- 36th Air Division, Davis-Monthan AFB, Ariz.
- 813th Air Division, Mountain Home AFB, Idaho
- 802d Air Division, Schilling AFB, Kan.
- 821st Air Division, Ellsworth AFB, S. D.
- 18th Air Division, Fairchild AFB, Wash.
- 4136th Strategic Wing (M), Minot AFB, N. D.
- 13th Air Division, Francis E. Warren AFB, Wyo.
- 12th Air Division, March AFB, Calif.
- 14th Air Division, Beale AFB, Calif.
- 47th Air Division, Castle AFB, Calif.
- 810th Air Division, Biggs AFB, Tex.
- 819th Air Division, Dyess AFB, Tex.
- 4141st Strategic Wing (H), Glasgow AFB, Mont.
- 703d Strategic Missile Wg., Lowry AFB, Colo.
- 4134th Strategic Wing (H), Mather AFB, Calif.
- 4128th Strategic Wing (H), Amarillo AFB, Tex.
- 4133d Strategic Wing (H), Grand Forks AFB, N. D.
- 4061st Air Refueling Wing, Malmstrom AFB, Mont.
- 4170th Strategic Wing (H), Larson AFB, Wash.
- 5th Bombardment Wing (H), Travis AFB, Calif.
- 6th Bombardment Wing (H), Walker AFB, N. M.

SIXTEENTH AIR FORCE
HQ Torrejon AB, Spain

Maj. Gen. H. K. Mooney, Commander

- 65th Air Division, Torrejon AB, Spain
- 3973d Air Base Group, Moron AB, Spain
- 4310th Air Division, Nouasseur AB, Morocco
- 3977th Supply Sq (POL), San Pablo AB, Spain
- 3974th Combat Support Gp., Zaragoza AB, Spain

1ST MISSILE DIVISION
HQ Vandenberg AFB, Calif.

Maj. Gen. David Wade, Commander

3D AIR DIVISION
HQ Andersen AFB, Guam

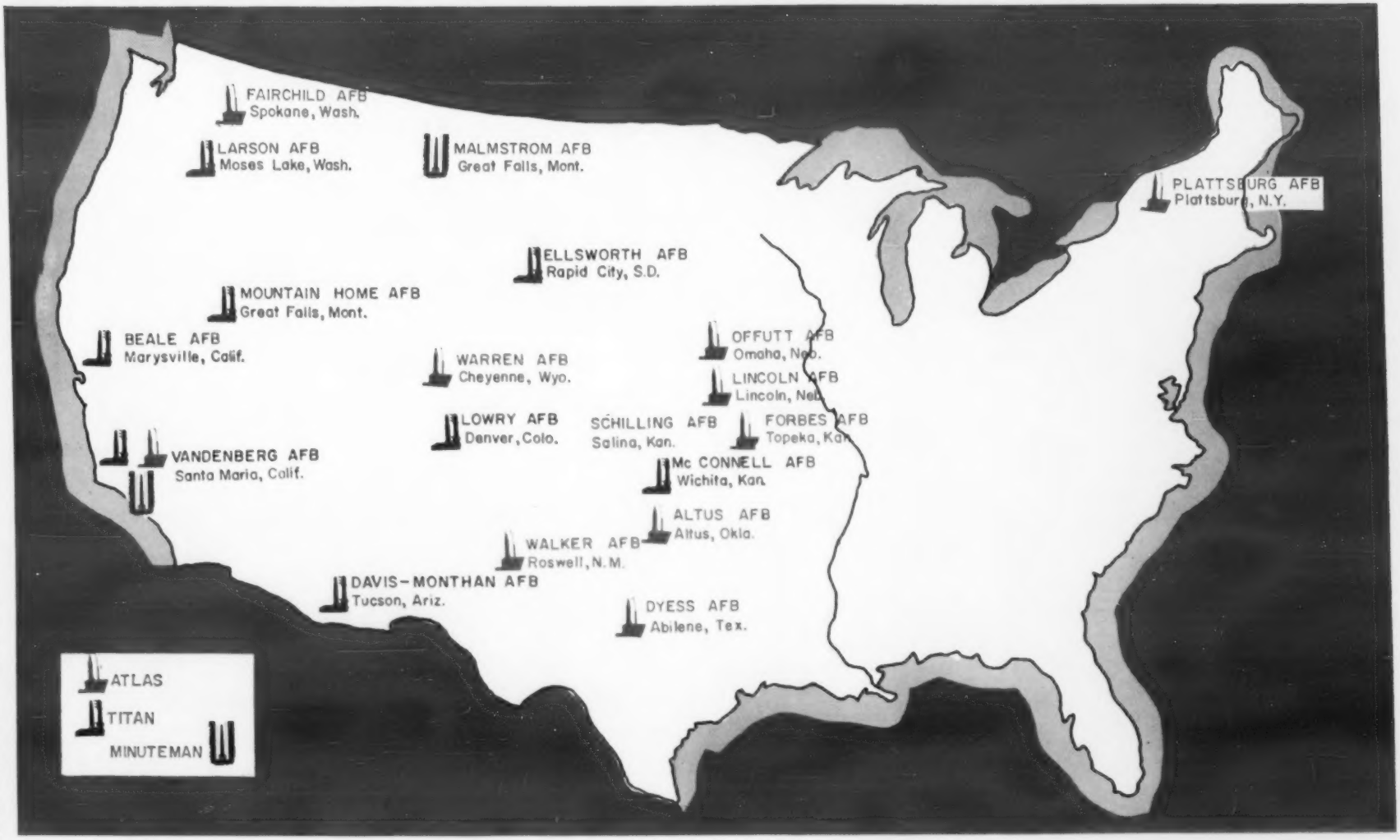
Maj. Gen. John M. Reynolds, Commander

7TH AIR DIVISION
HQ South Ruislip, England

Maj. Gen. Charles B. Westover, Commander

*Only combat units are listed. Appropriate support organizations are deployed to provide required logistical support.

Strategic Air Command Intercontinental Ballistic Missile Sites



KEYSTONE of Strategic Air Command's deterrent capability is the Boeing B-52 bomber, shown here in formation.

B-52 Force Functions as SAC "Big Stick"

Constant refinement in equipment and tactical doctrines are key factors in maintaining the useful life and deterrent capablity of Strategic Air Command's "big stick" fleet of Boeing B-52 heavy and B-47 medium jet bombers.

Faced with severe limitations in funding desired programs, positive and ingenious approaches have been made by the SAC-industry team to increase the capabilities of the force in being and to maintain the proper posture to deter Soviet war planners.

Among the important programs that have been developed are:

• **New models of the Stratofortress,** including the B-52G and B-52H, providing important range extension and missile platform capabilities greatly adding to Soviet defense planning problems.

• **Highly effective alert programs,** including the 15-min. ground alert concept, which postures a significant portion of the strike force for rapid retaliation, plus dispersal and quick-reaction techniques. The airborne alert concept, a further refinement of the ground alert, is designed to ensure survival of a good portion of the strike force in a period of no warning.

• **Attack procedures,** including low-level penetrations designed to complicate the enemy's detection and aerial defense systems.

Although the B-52 probably will be obsolescent in the mid-1960s, considering a normal useful life of some 10 years for a basic military design, the programing of the North American B-70 Valkyrie Mach 3 heavy replacement is such that the Stratofort will obviously be carrying the main deterrent load for many years to come, in the manned weapon system inventory.

To a generation entranced by the exotic performances of ballistic missile weapons, it is sometimes difficult to comprehend why SAC places so much emphasis on manned weapon system development and inventories.

Manned Weapon Advantages

Manned nuclear delivery systems have these important advantages in SAC's modern armory:

• **They can be launched,** under positive control, at the discretion of the SAC commander or his authorized officers, with the certain knowledge that, should the reason for sending them off from their bases turn out to be a "false alarm," the aircraft can be returned, even in event of a freak communications breakdown. The very fact that aircraft can be exercised and noted by enemy intelligence is a deterrent, whereas silent, underground missiles may not provide the same psychological impulses.

Under similar circumstances of warning, missiles would have to ride out the initial attack, should one actually develop, and the numbers, configuration and posture of such a force would be among the determining factors as to whether sufficient quantities would survive to provide an effective counterblow.

• **Ability to carry several much larger** warheads in each aircraft, longer distances and dispose of them with considerably greater accuracy on one or several targets during one sortie than missile systems can ensure, appears to favor a requirement for manned systems even when missiles are available in considerable numbers.

Bomber accuracies, are measured in feet, whereas those of missiles are still measured in miles. Lesser accuracies can be offset by higher weapon yield, but the yield of a missile warhead is but a fraction of that of the nuclear warheads carried by manned bombers, Gen. Power notes.

• **Manned system has the ability** to seek out targets on which perhaps only fragmentary data is available and score on it accurately. It can report on the success or failure of its mission, and return with valuable strike and other intelligence information. Unlike the one-shot missile, manned system has recycle capability for follow-on strikes.

Boeing B-52 Stratofortress heavy bomber now provides SAC with the capability of carrying the heaviest, largest yield weapons, longer distances with greater accuracies than any other system due to enter the inventory for years to come. It is a delivery system with which the command has considerable experience and it has proven reliability.

Constant modernization programs have developed the system to where early airplanes are considerably im-

proved over the time when they initially left the factory. Newer models, such as the B-52G and B-52H—the former first delivered to SAC in February 1959 and the latter scheduled to be delivered next year following initial rollout this October—resemble earlier models superficially, but under the skin and in strike capability considerably increase SAC retaliatory strength.

B-52 Lightweight Program

Major basic improvement in these models has been important extension in non-refuel range, permitting them to probe deeper and stay longer in enemy territory than previous models, thereby increasing SAC's targeting capability. Range extension has been provided by major redesign of the structure, starting with the B-52G, shaving some 10,000 lb. from the airplane compared with the previous model, and making possible increases in payload, primarily fuel. B-52G range is increased approximately 15% over earlier models.

Major portion of the lightweight program, conducted at Boeing Airplane Co.'s Wichita, Kan., Division—sole source for the Stratofortress since the B-52G—involved redesign of the wing structure. By reducing the amount of interior structure, engineers were able to greatly increase interior fuel storage, replacing earlier fuel bags with a wet wing configuration.

Main wing section now is composed of 80-ft. extruded 71-78 ST aluminum alloy panels with extruded stiffeners on the upper sections and riveted-on stiffeners on the lower wing skin panels forming the in-spar area. Extruded panels cover some two-thirds of the wing span and make possible fuel storage in nearly the whole in-spar area out to the external underwing fuel tanks. The latter have been reduced approximately 25% in size, providing additional range through drag reduction. They also have been made fixed instead of droppable to lessen maintenance.

Wing redesign also provides important reduction in maintenance: with elimination of bladder type fuel cells, tubing between these tanks is gone and the entire wing fuel operating system is placed in the wet wing area. Electrical wiring, formerly routed along the wing trailing edge, forward of the flaps, has now been routed through the leading edge, made accessible by use of hinged panels. Feeling is that this location is less susceptible to damage than was former location. Additional saving in weight and maintenance has been made on the G-model by eliminating the earlier B-52 aileron system and going completely to use of spoilers for lateral control.

Further areas which received the lightweight treatment include the tail gunnery section. Gunner was moved forward into the crew compartment, where he monitors his weapons via television equipment, deleting need for pressurization, oxygen, communication and other services in the tail area, cutting weight and further reducing maintenance.

Important weight savings were made by reducing fin height some 25% from that of previous models; with lessening of loading on the fuselage because of the smaller tail, Boeing-Wichita engineers were also able to move into the fuselage and lighten some of the structure there.

The B-52H is basically a B-52G with an additional range extension cranked in by fitting new Pratt & Whitney TF-33 turbofan engines, providing approximately 12% better fuel consumption than the B-52G's P&WA J57-P-43W turbojets. Installation of the more powerful TF-33 turbofans permitted elimination of some 10,000 lb. in water injection. Additional weight is saved by replacing the four .50-cal. guns fitted in earlier B-52 tail turrets with a rapid-fire lighter weight Gatling-type weapon on the H.

It is sometimes difficult to completely assess the value of these changes. Increase in range is obvious, but reduction in maintenance time or elimination of some parts may provide a gain in combat efficiency that only a SAC war planner can appreciate.

Making an airplane less susceptible to being taken out of commission because of lack of a replacement part, or making it possible to take hours off a maintenance procedure may make the difference as to whether this multi-million dollar weapon ever gets to play its important role should the alert horn sound in the ready building. Such achievements are appreciated best by those who know how maintenance crews sweat to shave minutes off the time to pre-flight an airplane or get it back into the war plan once it has been uncocked.

Lowering the floor in the B-52G and H cockpits some eight inches, making it possible to observe the refueling operation more easily, can only be appreciated by a B-52 pilot, who strained backward in earlier models during a long mission to monitor the procedure, thereby cutting his efficiency by building up fatigue. Putting in folding rudder pedals so that the pilots can stretch their legs during long, tiring missions may not seem to rank high to a budgeteer sharpening his pencil, but together these modifications put a bigger wallop in SAC's nuclear delivery systems.

The versatility afforded by manned systems has been highlighted by adaptation of the Stratofortress to the missile platform role—a major step forward in bomber employment and a serious problem to an enemy defense planner.

The North American GAM-77 Hound Dog air breather will be carried in multiple installations under B-52 wings. The supersonic 43-ft.-long Hound Dog nuclear delivery system, powered by a 7,500-lb.-thrust P&WA J52, can take out strategic targets or sweep aside enemy ground-based defense systems. With the NAA Autonetics' inertial guidance system under control of the B-52's navigator up to the time of launch, the GAM-77 Hound Dog's cruise altitude to a target can be modified; changes in target can be made even after the B-52 becomes airborne.

Important feature of the Hound Dog is that, since its powerplant can be used to augment takeoff power of the bomber's eight jet engines, fitting it does not incur a takeoff weight penalty. This means that B-52s fitted with Hound Dogs could take out strategic targets thousands of miles apart during a single mission.

Indications are that it will be possible to retrofit the Hound Dog installation on many early models of the B-52, greatly increasing their potential.

Skybolt Program

A later more sophisticated missile program, the Douglas GAM-87A Skybolt solid-propellant air-launched ballistic missile system, is now under development. High speed—about 5,000 mph. after launch, substantially higher on re-entry—and longer range—1,000-1,500 mi.—along with more complex and advanced target programing systems (AW Feb. 22, p. 26), make the Skybolt a logical successor to the Hound Dog, which probably will be phased out of the B-52F, G and H as the Skybolt phases in during 1961. Earlier B-52 models probably would retain Hound Dog-type GAMs since they would not be capable of accepting the takeoff weight penalty without marked decrease or elimination of internal nuclear stowed weapon capability.

These missiles permit additional upgrading of SAC's confidence factor in the ability of its manned delivery systems to penetrate enemy air defense systems. Bomber offensive techniques and tactics have benefited from scientific advances as much, or more, than defensive techniques. So far as attrition from ground defenses are concerned, in World War II, ground defenses were generally neglected because they were not considered worth attacking. In a nuclear conflict, however, air defense systems would be a priority target and would be hit by the most effective countermeasure known today—hydrogen weapons—each successive bomb clearing a wider area and permitting deeper penetration.

Electronic countermeasures—an important portion of every bomber aircraft's strike capability today—would also help pave the way toward entry and

exit from enemy territory. As air defense systems become more sophisticated, they rely to an increasing extent upon electronics—which in turn are susceptible to electronic countermeasures.

Decoy systems, such as the McDonnell GAM-72 Quail, would be one of the techniques practiced to saturate and confuse enemy ground defense radars. The 10-ft-long GE J85 turbojet-powered missile, soon to enter the bomber force, can be sent off on a different path from the bomber it is protecting at the same speed, providing identical reflectivity on the ground radarscopes to divert the enemy. Launchings have been made from B-47s and B-52s-missile's small size and folding-fin configuration take minimum bomb-bay area, making possible stowage without interfering with nuclear load.

GAM-72 QUAIL diversionary missile built by McDonnell Aircraft Corp. is used by the B-47 and B-52. Powered by a General Electric J85 engine rated at 2,500 lb. thrust, the 1,100-lb. missile has a range of about 200 naut. mi. at a maximum speed of Mach 0.90.

B-47 Plans

The B-47, scheduled to be replaced by the supersonic Convair B-58, which is feeding into the Air Force at a slow rate due to limited funding, apparently has reached the end of the road so far as extensive modernization programs are concerned. It is too close to retirement for economical development of air-launched missiles to increase its capabilities, since such programs could not become operational within the airplane's limited remaining useful life.

SAC has started disbanding some B-47 outfits, with crews entering B-52 units and the B-58 program, but the aircraft of these deactivated units will be utilized to strengthen remaining B-47 wings. Plan is to add approximately 10% to the normal unit equipment strength of existing wings with phased-out B-47s, in effect providing these wings with higher in-commission strength at all times since the additional aircraft can fill slots temporarily vacated by airplanes taken out for maintenance.

The B-47 is still useful, particularly in providing a retaliation capability at overseas bases where Stratojets are regularly sent on Reflex missions to stand 15-min. ground alerts. Shorter distance to the target puts less strain on SAC's limited tanker strength.

Constant exercising of the B-52 and B-47 force in realistic combat-type missions keeps crews at high proficiencies demanded by the Command, with the program geared to promote hard competition between all units. Training is never static or routine; crews must maintain high grades to conform with requirements posed by their pre-selected targets. In the U.S. alone are some two-score radar bombing sites located near cities selected to give crews optimum conditioning to the type of targets they would encounter on runs over actual enemy territory. Accuracy is constantly stressed on all phases of these missions—a bad job on a run, for example, means that you owe the Command five perfect ones, as one crew member explained. Proficiency of the unit and its standing in the war plan control spot promotions for the crews.

Training requirements constantly change as new tactical procedures are approved and made operational requirements. Most tactical maneuvers are classified, but one approach which is now required as part of unit proficiency is the low-level penetration technique, designed to avoid enemy radar detection and tracking.

B-52 and B-47 crews participate in Operation Oil Burner, as this maneuver is coded, to perfect penetration techniques involving flight at 2,000 ft. above the terrain or lower, day and night in all types of weather.

Seven Federal Aviation Agency-approved routes are utilized by the bombers during two five-hour periods five days a week.

Ground Alert

While crews participate daily in training and simulated combat missions, they also stand ground alerts, during which they move out to quarters close to the hardstands on which their airplanes are postured to take off in 15 min. or less.

Approximately a week before going on ground alert, the crews enter the highly guarded "Vault" room on the base, which contains target folders covering actual combat missions. They spend some seven hours learning new target systems, since their alert-status targets differ from the normal targets assigned them—also target information or procedures change constantly.

At the alert building, personnel put in seven full days away from home, ready to take off within 15 min. after the klaxon sounds.

Aircraft stand ready on the nearby ramp, positioned for quick and easy access to the main runway, and are set up in a so-called "cocked" configuration: containing the proper weapon load for the target assigned each crew plus all the equipment necessary for the mission, including flight gear, target data and proper fuel loads. Ground starter units are hooked up. Switches are placed so that all the pilot must do is to hit the starter buttons.

A four-man ground crew is assigned each airplane from maintenance, working in pairs on a 24-hr. on, 24-hr. off schedule through the alert periods. During their duty time, ground crews run hourly checks on each airplane and rotate the wheels periodically to prevent flat spots as the airplane rests at takeoff gross planned for its mission. Ground crews have number one priority on parts; technical assistance from the base, if required, is tied into a direct radio net. Necessary maintenance is performed on the ramp and everything possible is done to speed the process, since anytime the airplane is not ready to go immediately it is uncocked and a substitute must be configured to the same mission as standby or replacement.

The speed with which these crews worked was illustrated here during one instance at the alert hardstand, Carswell AFB, Tex., when two wheels on an alert KC-135 were changed in 19 minutes, after the tires were discovered to have cuts.

Flight crews keep a busy schedule in the alert building, with four-hour ground schools to attend on weapons, navigation and electronics and a five-hour ground school on flight planning.

Alert periods may be interspersed with test alerts at anytime, sending crews pouring out to the airplanes to time their reaction. Sometimes the practice is called off just before the starter buttons are hit; or it may continue up to the time the airplanes reach the runway for takeoff.

Exact percentage of the force on alert is secret but SAC says its goal is to have one-third on constant alert.

CONVAIR TB-58 Hustler two-seater trainer version, carrying weapons pod on belly, makes its first flight at Ft. Worth, Tex.

SAC Gains Powerful Deterrent in B-58

Considerable increase in target penetration capability will be provided Strategic Air Command's manned nuclear delivery force this year as the new supersonic Convair B-58A Hustler medium bomber phases into the inventory to supplement the obsolescing Boeing B-47 Stratojet.

The Hustler's ability to attack at altitudes well over 50,000 ft., where it has Mach 2-plus capability, and at near sonic speeds just clearing ground obstacles to avoid electronic detection and tracking systems, is certain to greatly complicate the Soviet Union's air defense problems and provide SAC with a major gain in war deterrent potential. Airplane's cruise speed is higher than any previous bomber's top speed.

Performance of the weapon is considerably enhanced by highly sophisticated electronics systems automating most of the flight processes and providing high degrees of accuracy in navigation and bombing. Sperry Gyroscope inertial bomb-nav system is invulnerable to countermeasures and frees the crew from the necessity of making detectable earth checks, although radar fix and astro-tracking systems are also available for check and standby.

High-density design necessitated putting weapon and some fuel in external ballistic missile configured pod, which obviates need for airplane carrying conventional bomb-bay and its necessary deadweight equipment on the return mission. Pod concept also makes possible design to fit specific weapons, taking advantage of improvement in yield to modify configuration to optimum size.

Pods have been engineered to fit the Hustler for a wide variety of roles including electronic reconnaissance (pod designed for this mission is capable of containing "unusual" antennas not possible to stow in other aircraft), air-to-surface ballistic missile capable of extending striking range by considerable distance without the need for the carrier to penetrate close to the target, and photo reconnaissance pods.

Actual tactical pod to be carried by production B-58As is a refined version of earlier one-piece units that stowed both weapons and fuel. New two-component pod has a lower portion, containing fuel, nesting into the upper, weapon carrier. This system permits dropping the lower portion after exhausting fuel, with considerable decrease in drag and consequent improvement in range over the previous single pod, conceived as being carried all the way to the target.

Initial missile pod died an early death, but Convair has continued studies on this weapon concept to the extent of planning and prototype test launching air-launched ballistic missiles from the B-58, to be carried externally in addition to the nuclear weapons pod.

Indications are that these airplanes could provide valuable experience for the forthcoming Mach 3 North American B-70 Valkyrie heavy bomber replacement for the Boeing B-52 and for supersonic transport development. Actually, some test B-58s will be utilized in studies to aid both these fields. National Aeronautics and Space Administration has indicated interest in using a Hustler for studies on supersonic transport aerodynamics problems.

Test and development program on the B-58A is nearing its decisive last phase at Carswell AFB, Tex., and indications are that Strategic Air Command will take over executive management of the program this summer. The 43rd Bomb Wing, activated at Carswell last Mar. 15, as the first unit to be outfitted with Hustlers, will then have the responsibility for the final—Category III—phase of the test program, which is to evaluate the weapon system's capability to be operated in numbers on a sustained basis in accordance with SAC mission requirements.

Currently, Air Research & Development Command has completed 95% of its responsibility—Category II—and in the words of B-58 Test Force Director Col. D. M. (Davey) Jones, with some 135 Hustler hours in his log, "We [ARDC] are in good shape and are now cleaning up odd tasks."

Col. Jones is particularly pleased with progress on the Hustler's bomb-nav system, which he expects will be in better shape when airplane number 35 rolls out than the B-47's system was by the time the 400th airplane of that series came out.

He rates the airplane's handling characteristics as sensational, noting that even on low-level penetration evaluation flights, the delta-wing configuration seems to ride out low-level turbulence much better than conventional aircraft. He also pointed out that pilot fatigue is noticeably lessened on long-distance missions because the airplane's high speed produces shorter missions.

B-58 Test Force has accomplished some 20 missions to demonstrate the airplane's combat capabilities. These include a nonstop 18-hr. 10-min. flight covering more than 11,000 mi., including two air refuelings, with most of the demonstration flown at 620 mph.; a low-level penetration flight from Carswell AFB to Edwards AFB, Calif., maintaining a maximum altitude of 500 ft. above terrain, with a portion of the flight at 200-ft. altitude and the airplane maintaining a speed of almost 700 mph.; and a high-level penetration flight which includes an air refueling and a one-hour dash at 1,300 mph.

The B-58 Test Force that has brought the Hustler along through its development program is a novel organization formed as a result of a major change in the USAF system of a long and tedious eight-phase test program during which new aircraft moved from the contractor through various test facilities to accomplish development, evaluation and user trials. To cut valuable time out of this program, the system was revised to a three-category program, under which the using command is brought into the development and evaluation program early and is also able to concurrently train pilots and maintenance personnel in the new weapon.

Because of the B-58J's complexity, its program went one step further and was located at a SAC base, Carswell, across the field from Convair-Ft. Worth, the builder.

Following Category I tests, which had as their objective verification of sound airplane and subsystem design, a special unit, the B-58 Test Force was activated at Carswell early in 1958 to handle Category II—development and evaluation of the complete weapon system. Management responsibility was ARDC's, with Strategic Air Command and Convair-Ft. Worth providing support. The B-58 Test Force was composed of two units: The 6592d Test Sqdn., representing ARDC, the test director, and the 3958th Operational Evaluation & Training Sqdn. (later group), representing SAC, the using command.

The 6592d was concerned primarily with its responsibility for Category II evaluation of the system, although because of early production slippage, it inherited aircraft still assigned to Category I tests including speed-power determination and a pod drop mission, which it performed. Pods have been dropped up to Mach 2.

The 3958th carried broader responsibilities, not only of acquiring B-58 know-how and supporting ARDC, but also planning a combat crew training program for the day the airplane was assigned to specified wings, and developing maintenance personnel and a cadre of flight crews to serve as instructors for the eventual combat crew training classes, plus compiling the standard operating procedures to be used by future SAC B-58 wings.

Requirements that ARDC carry out its test function and that SAC build up to an operational capability means that the B-58 crews are often a mixture of both commands. It is not uncommon for a test airplane to take off on an ARDC mission, with perhaps a SAC pilot and ARDC crewmen riding the bomb-nav and defense system operator seats, or any combination of the personnel in these positions.

Last March, the organization underwent a significant change when Col. James K. Johnson, former F-86 double ace in Korea and 3958th commander, left Carswell AFB in a B-58A for Davis-Monthan AFB, Ariz., and en route became commanding officer, 43d Bomb Wing (Medium), the first unit authorized by SAC to receive the Hustler.

The 43d includes the 63d and 64th Bomb Sqdns. and the 65th Combat Crew Training Sqdn. The 65th CCTS will receive the first Hustlers, including those handed over by ARDC when it completes Category II tests and relinquishes management of the program to SAC. When this happens, the B-58 Test Force will be formally dissolved, although a nucleus of ARDC personnel will stay with the Category III phase of the program to assist the 43d.

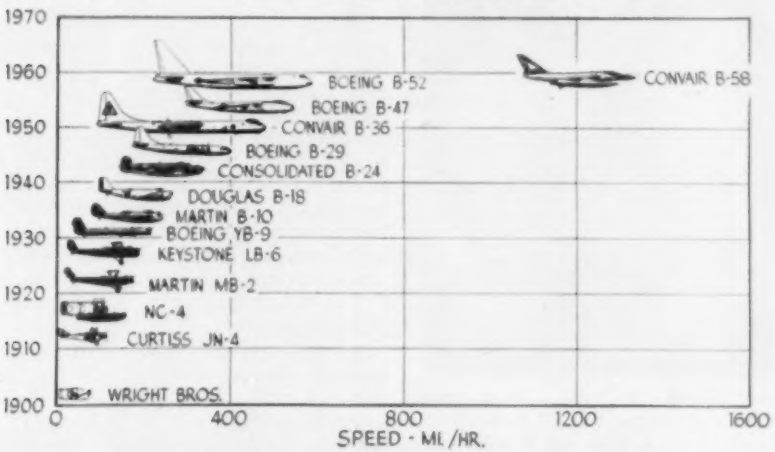
The 65th recently started its first formal three-month classes for combat air crews at Carswell AFB. Personnel are the "cream of the crop" of SAC B-47 crews, 65th Commander Lt. Col. Leonard M. Legge noted, with selection being made from study of candidates' folders, rather than by the numbers. Most are regular officers. Pilot minimum requirements include 1,000-hr. total jet time with 500 hr. of this after upgrading to aircraft commander and at least one year as commander on a SAC senior or select crew. Navigator requirements include 500 hr. on multi-jet SAC aircraft, having held the navigator post for one year in a SAC senior or select crew and having passed the ASQ-42V bomb-nav course at Mather AFB. Defense system operator (formerly Electronic Warfare Officer) requires at least 200 hr. on SAC multi-jet aircraft and six months experience as EWO on a SAC senior or select crew.

Pilots will take initial training in Convair two-place TF-102A airplanes to acquaint them with the characteristics of delta wing aircraft, spending the approximately 10¼ hr. of this training with a B-58 instructor-pilot. B-58 flying training will total about 50 hr.

Curriculum is planned so that the bombardier-navigator and defense system operator enter the academic phase at Carswell 10 days after the pilot, due to their requirement for taking specialized courses in their equipment for the rear two seats. From the 10th day on the crew is attending school simultaneously at Carswell and will graduate together. The entire crew begins flying together in a B-58A on the 30th day of the curriculum. When the equipment becomes available later this year, the crew will also fly simulator missions together.

Next month the TB-58, two-seater trainer version will begin to phase into the SAC training program and only one TF-102A familiarization flight will be required. Three TB-58 flights will be made before pilots solo in the B-58A.

First two or three missions flown by the crew in the B-58A will duplicate earlier missions which they have prepared for in the simulators.



DRAWING illustrates vast range of speeds attained by operational aircraft in 50 years.

Tankers Give SAC World-Wide Capability

Tankers provide the flying pipeline which makes Strategic Air Command's bomber force a truly intercontinental power. They are also the key to the airborne alert capability SAC plans to use as its basic deterrent during the critical years of transition to a significant ballistic missile capability.

SAC has developed a refueling capability over the past dozen years that enables the command's turbojet bombers to strike any target on the Communist land mass and return. Now SAC is building a turbojet-powered tanker force that can deliver more fuel, higher and faster than propeller-driven tankers and which has the capability to refuel future bomber types as they come into use.

As the nation moves into a period of missile peril over the next three years, tankers will be the key to the manned bomber deterrent upon which the U. S. will have to rely. Only with an effective air refueling capability can SAC hope to maintain the airborne alert generally considered the main deterrent available to the U. S. during the missile gap years.

Tankers now stand alerted with the 30% of the SAC bomber force which will be airborne within 15 min. warning time. When the time comes to operate an airborne alert, the tankers will be the workhorse element which can keep up to a quarter of the B-52 force in the sky, invulnerable to surprise attack. This air alert concept has been tried and found feasible.

SAC's refueling capability is built around a large force of piston-engine Boeing KC-97s, plus a growing force of turbojet Boeing KC-135s. Air Force has asked Congress for $224 million in Fiscal 1961 to continue KC-135 deliveries and provide enough tankers to completely equip the planned Fiscal 1963 force. Although deliveries are continuing, economy strictures are reducing the production rate from 15 a month last year to the current level of six a month.

Early Refueling Operations

Refueling operations began a dozen years ago when SAC decided aerial refueling was a practical answer to the need for extended bomber range. Two squadrons using converted B-29s and B-50s developed a fuel transfer capability by the end of 1948 to stretch the range of B-29 and B-50 bombers. Six squadrons were flying by the end of the following year.

SAC got its first Boeing B-47 in 1951, three months after deliveries began on the KC-97. This tanker was a cargo transport converted with the installation of 15 fuselage tanks and a boom system which could pump 600 gal. a minute into a bomber. After experimenting with both types, SAC chose the boom technique over probe and drogue refueling.

The KC-97 has served successfully in large numbers to refuel both the B-47 and B-52 fleets, but there was an obvious need for a tanker with performance closer to that of the bombers themselves. Air Force decided to adapt the Boeing 707 design for its needs, and the KC-135 was ordered. Similar to the 707, the KC-135 has fuel tanks installed under its cabin floor and behind the aft bulkhead.

This turbojet tanker offers SAC important advantages over the KC-97. With a 150,000 lb. load, it can carry more than three times the 45,000 lb. fuel load of the KC-97. It can also operate at altitudes up to 42,000 ft. and at speeds comparable to bomber speeds, eliminating the slow, costly process of descending to KC-97 altitude and refueling at KC-97 speeds. The KC-135 can outrun the B-52 and B-47, although the two bombers can climb faster.

First KC-135 was delivered to SAC in June, 1957, a year after the last of 888 KC-97s was rolled out. By the end of 1957, the last of the KB-29s was gone from the tanker fleet. Now the KC-135 is scheduled to gradually replace the KC-97, although the propeller-driven tanker will stay in service for some time.

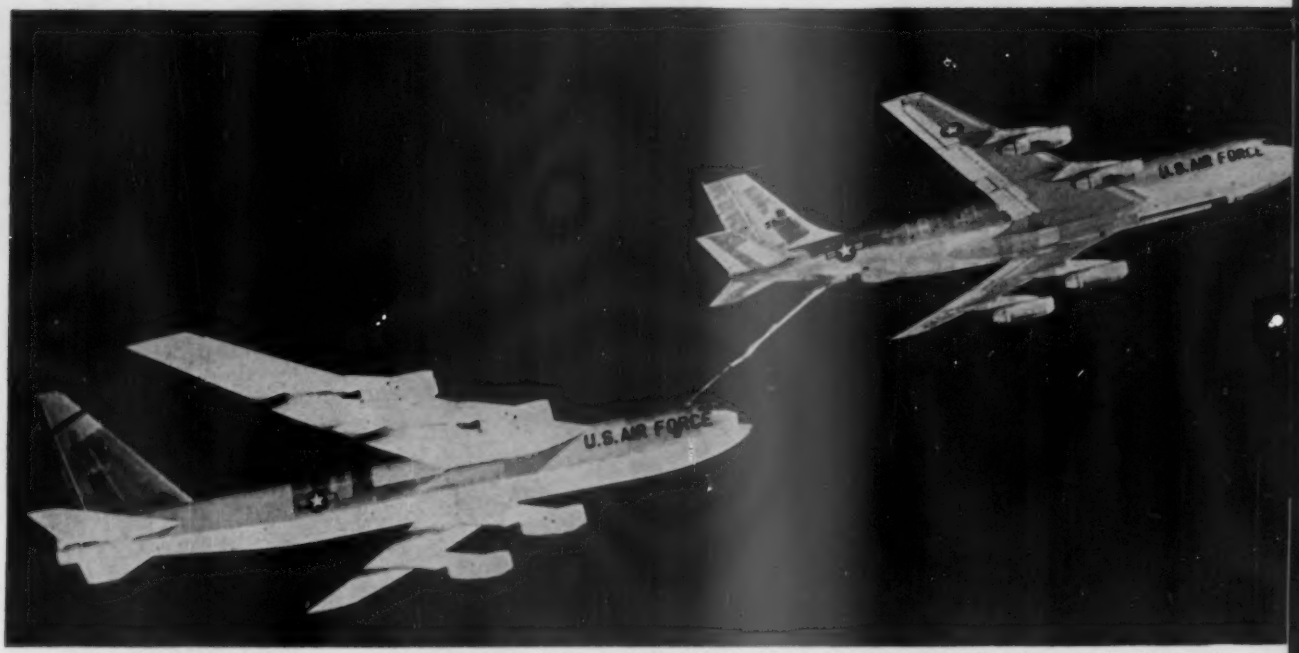
Feasibility of refueled long range bomber operations was proved several times over the years while SAC was developing its tanker capability. A B-50 flew nonstop around the world in 1949, and three B-52s did the same thing in 1957. During these years, refueling activity has increased to the point where currently a bomber is hooking onto a tanker every three minutes around the clock.

V-SHAPED ruddevator on boom of KC-135, operated through a hydraulically boosted cable system, provides additional control. Boom is extended and retracted by a left hand control; right hand control stick enables boom operator to fly it up or down and to either side. Note Hound Dog missiles under wing of B-52.

Refueling Tactics

Tanker tactics are simple—meet the bomber and refuel it. The planning and management required to accomplish this in a large operational pattern are not so simple. The overall mating pattern for the tanker and bomber fleets is plotted with the IBM 704 computer system which stands adjacent to SAC's underground War Room at Offutt AFB headquarters. With this pattern established, the plan is checked by hand and converted into individual flight plans.

The refueling pattern is intricate. Although bombers and tankers are based together, the tankers from a given base generally do not refuel the bombers stationed with them. The most efficient refueling tactic is to fly to a rendezvous shortly after takeoff, transfer fuel and land. This way, the tanker



BOEING KC-135 Stratotanker, seen refueling Boeing B-52, carries 150,000 lb. fuel load and can operate at altitudes up to 42,000 ft. and at speeds comparable to those of the B-52. SAC bomber-tanker hookups occur every three minutes around the clock.

burns a minimum of the fuel itself and has a maximum amount available for its refueling mission.

Under such an approach, a tanker would take off considerably later than the bomber it is to refuel. Ground alert tactics have altered this scheme somewhat since both bombers and tankers must get into the air within 15 minutes, and tankers cannot wait until the most efficient time to take off for their rendezvous. This new condition calls for close planning to obtain a minimum of tanker time orbiting at a rendezvous point in wait for the assigned bomber.

Tanker crews live and operate under the same alert procedures as bomber crews. Tankers sit fully loaded and ready to start engines at the alert signal. Crews live in alert facilities similar to bomber crew facilities, ready to start their aircraft and follow the bombers down the runway. They apply the same "hurry-up" tactics, and just as B-47s have experimented with minimum interval takeoffs in the Open Road project, KC-97s have taken off at the rate of six per minute using the same techniques.

Loaded tankers also are located at strategic points on strip alert duty. They sit at the edge of the runway ready to take off and refuel bombers in emergency situations. They can furnish enough fuel to get a bomber home safely, or they can refuel a bomber that has to stay aloft while mechanical problems are solved.

Once a tanker comes off alert duty, it is flown to exercise all the systems which have stood ready to fly for a week. It also provides a chance to offload the maximum fuel load which is carried in alert tankers, but which is more than the normal tanker load. These post-alert flights are made as training missions. Tanker crews fly an average of seven six-hour flights a month.

These training flights, made under a variety of conditions, simulate the types of flights the tankers would fly in combat operations. They maintain the proficiency of both tanker and bomber crews, since fuel is offloaded on each flight. Typical of this pattern was a flight made by a KC-135 of the 99th Air Refueling Squadron from Westover AFB, Mass., and observed by AVIATION WEEK.

Briefed the previous day on their mission and on weather and communications, the crew assembled in its KC-135 two hours before taxi time for a check on the aircraft status and on mission details. Then they separated for a preflight check.

Training Mission

The tanker was loaded and ready to fly. The aircraft are refueled through their single point system in the right wheel well as soon as they land. This quick reloading, a 20-30 min. job, avoids condensation problems and keeps the tanker ready to go on short notice.

The crew proceeded to Operations to file a flight plan that laid out a mission generally south and west of Westover AFB. Weather moving up through the south indicated possible problems in that area. The crew returned to the aircraft, assembled for last minute briefing and reports, then moved on to the final checks before starting engines. The KC-135, coded Honk 14, taxied to the end of the runway 30 min. before takeoff and parked with engines idling at 62% power.

Flown by Capt. Jerome Williams and copilot 1st Lt. John Edgerton, Honk 14 took off with a gross weight of 263-000 lb., including about 100,000 lb. of fuel. The tanker climbed to 36,000 ft. and leveled off along an initial leg to a check point near Nashville, Tenn.

After takeoff, boom operator Sgt. Robert Neil checked out his refueling equipment, lowering and extending the boom and flying it from a pad below the rear cabin floor. The boom operator has a control panel which shows him the condition of the system and provides instruments to show the flight attitude of the boom, including azimuth, elevation and the length to which the telescoping boom is extended.

The boom is extended and retracted by a left hand control; a right hand control stick flies it up and down and to either side. V-shaped ruddevators on the boom, operated through a hydraulically boosted cable system, provide additional control.

Although the pilots could navigate in the U. S. with their radio or omni equipment, navigator 1st Lt. Walter Black charted the mission on a grid system of the type that would be necessary in polar regions where longitudinal meridians merge and magnetic compasses register wide variations from true north.

The tanker is equipped with Doppler radar to provide ground speed and drift,

and this data can be fed into a computer along with true airspeed and compass heading to provide a position readout in longitude and latitude. With grid navigation, a free-floating gyro compass oriented to grid north is utilized.

Navigators get quarterly training in the techniques used to supplement the basic dead reckoning system. These include two hours each of night celestial, night grid, day grid and radar grid navigation and 1.5 hr. of pressure pattern navigation.

Navigator uses the tanker's nose radar to scan the earth's surface for features which can be used to check his plot. The crew also stays current in celestial navigation for use in case the radar should go out. The boom operator assists the navigator by taking the celestial fixes.

Making Bomber Contact

Nearing Nashville, Honk 14 turned left and flew toward its bomber rendezvous point in the vicinity of Spartanburg, S. C. Radio contact was made with a receiver B-47, one of four to be refueled, shortly before the tanker reached the rendezvous point and it began to orbit at 33,000 ft. Weather had moved in from the south and visibility was limited. The tanker descended through a hole to 24,000 ft. in search of a clearer area in which to meet the bombers.

Usually when a group of bombers is meeting a tanker, the bombers fly in a group or "cell" that can be easily located. Cell formation makes it relatively simple for the tanker to move into refueling position ahead of the bombers. In this case, the four B-47s arrived in the area on separate flight plans, making the rendezvous difficult in poor weather.

After searching for a clear refueling area, the pilot decided to fly toward Nashville and an alternate refueling area instead of making the planned refueling run from Spartanburg to central Virginia. The new route was cleared with Federal Aviation Agency Air Route Traffic Control, as were other legs of the flight.

Refueling Technique

Returning to the Nashville area, the receiver bombers began to make contact. The tanker was cruising at 24,000 ft. and 255 kt. when the first B-47 swung in behind it to hook up. Standard refueling speed is 255 kt. and the ideal altitude for the various tanker-bomber speed combinations is 30,000 ft. with the KC-135.

During the refueling run, the tanker pilot holds his aircraft straight and level, and the maneuvering is done by the boom operator and the bomber pilot. Some refueling is done with the tanker on autopilot, but most pilots prefer to fly the tanker themselves during fuel transfer. Boom operator controls the mating of the tanker and bombers, but the pilot handles fuel management through a simple panel and switch arrangement in front of the engine control quadrant.

In addition to its regular boom operator, Honk 14 carried Sgt. Adolfo Falcon, who was logging required quarterly refueling time. Sgt. Falcon extended the boom 10 ft., lowered it 30 deg. and held it centered as the first B-47 approached to take on 15,000 lb. of JP-4.

Automatic Refueling

As the bomber approaches the extended boom, its pilot maneuvers to get the boom nozzle into the transfer fitting in the B-47's nose. Both the boom and the fitting were lighted during this night refueling. The boom operator holds the boom steady while the bomber gets into position, then makes any final adjustment necessary to make contact.

When the nozzle is plugged into the tanker, it is clamped by two toggles in the bomber fitting and a signal system tells bomber and tanker crews that contact has been made.

Once the bomber is locked on, the refueling operation becomes automatic. The tanker flies straight and level, and the bomber pilot maneuvers to maintain contact within the flexibility envelope of the boom. The ball-joint boom nozzle has 20 deg. of movement in all directions, and the boom can be extended as far as 20 ft. Limit switches automatically stop fuel transfer, disconnect and retract the boom extension if the boom goes outside the envelope. When this disconnect is made, the boom operator flies the boom up and to his left to get it clear of the bomber.

Position Indicators

Bomber pilot can get some idea of his position relative to the tanker from fluorescent stripes painted on the boom extension.

Green marks show when the boom is extended its normal length, then yellow marks show on the extension tube when it is pulled out farther. Red marks come into view when the tube has reached its limit. Boom operator also has a set of directional lights on the bottom of the tanker which he can use to guide the bomber pilot.

Fuel transfer operations with Honk 14 provided refueling training for the B-47 pilots, some of whom were obviously still in the learning stage. It took a number of contacts and disconnects to transfer fuel to the bombers, although one of them remained connected through a complete 18,000 lb. transfer operation. This included staying on the boom while the tanker made a 180 deg. turn.

With the refueling completed in the Nashville area, Honk 14 turned for home. Original flight plan called for flying to central Indiana after completing the planned refueling over Virginia. Instead, the tanker climbed to 40,000 ft. and flew from Nashville to the Indianapolis area before making the right turn for home. The last leg was flown at 42,000 ft., and Honk 14 completed its eight hour mission with a GCA approach and landing at Westover AFB.

Missions like the flight of Honk 14 provide the kind of training that produces and maintains SAC's vital refueling capability. But the Command must also maintain a basic training program to prepare crews for SAC operations.

Crews for KC-97 training come from all parts of the Air Force, including navigators directly from Air Training Command. KC-135 crews generally come from KC-97 squadrons, although a pilot with 3,000 hr. can apply from elsewhere in USAF. KC-97 training is done at Randolph AFB, Texas, and KC-135 crews are trained at Castle AFB, Calif., and Walker AFB, N. M.

Training goal is to provide a crew that is familiar with the aircraft and its job and can work well as a unit in an emergency. Training flights involve all of the necessary aspects of refueling—pilot practice, navigator practice and fuel transfer.

Crew Curriculum

On the ground, KC-135 pilots get 184 hr. of ground school and 40 hr. of simulator time. Navigator gets 174 hr. and boom operator gets 173 hr. KC-97 ground school is similar, with the addition of 170 hr. for a flight engineer.

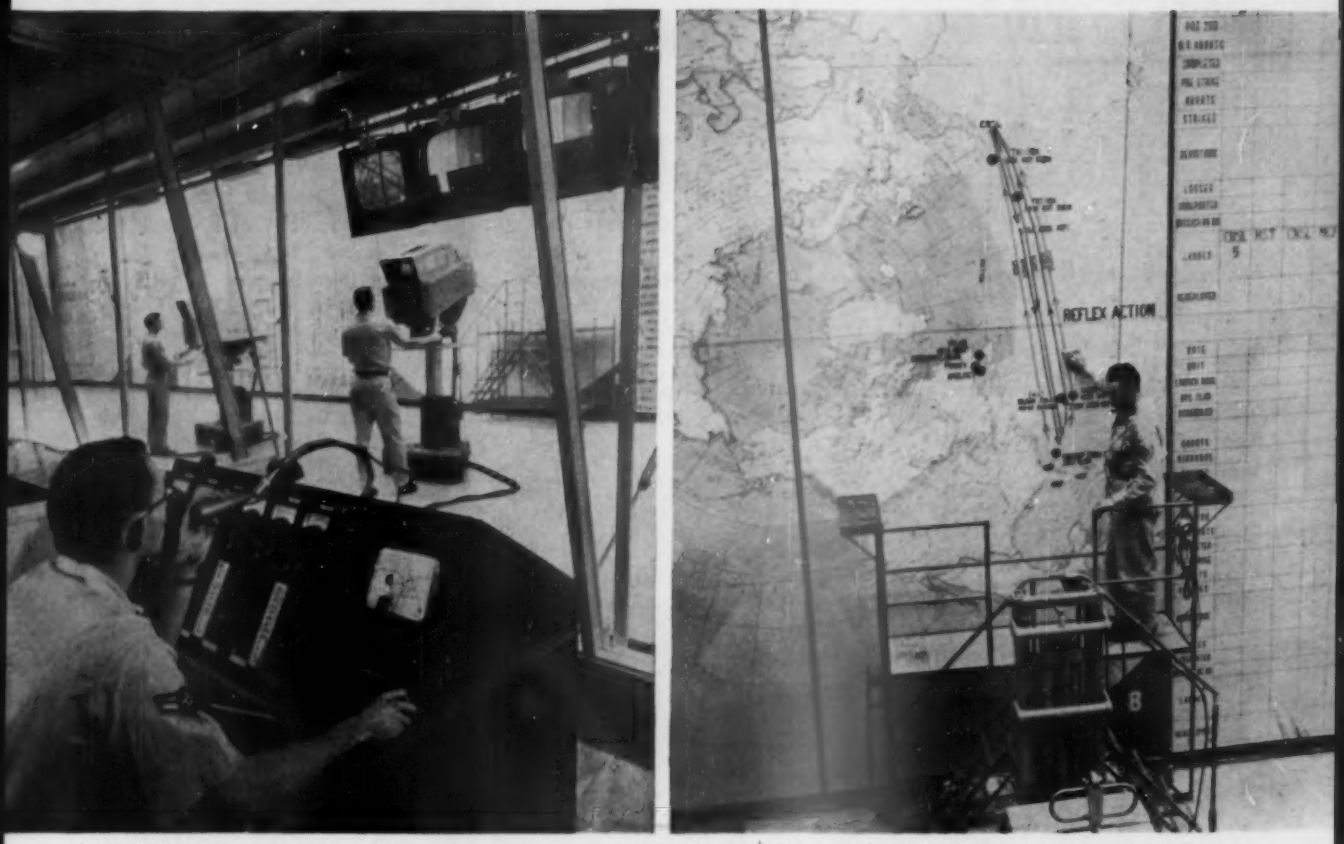
Crews get 72 hr. of flight time in training, then they train another 40 hr. to become combat ready after joining a squadron. SAC is pleased with the safety record this training program has produced.

Air Traffic Considerations

Air traffic considerations are a problem in refueling operations over the U.S., and SAC has been working with FAA to find solutions. Currently, refueling at altitudes over 24,000 ft. is limited to specific areas. At these altitudes, airlines are confined to corridors, and FAA can coordinate traffic control with SAC needs.

SAC has drawn another set of refueling areas for KC-97 operations below 24,000 ft.

FAA coordinates complete traffic control in these areas on IFR flight plans, but the agency does not have positive control at these altitudes on VFR flight plans.



CONTROL ROOM of SAC's underground command center displays battle situation, deployment of forces and other vital information on huge mobile display panels. Displays can be viewed in other portions of underground center by closed-circuit color television which also permits instant briefing of top SAC officers while in their above-ground offices. Joint Chiefs of Staff in Washington also has TV tie-in.

Command Post Controls Global Forces

Nerve center for all of the Strategic Air Command's global operations is a three-level hardened underground command center which extends 45 ft. below the ground level of SAC's Headquarters building at Offutt AFB, Omaha, Nebr.

The underground center can be sealed off from the outside world in event of war and can operate for 30 days using its own underground electric power, water and air conditioning systems. A nuclear blast within a radius of 50 mi. of Omaha will automatically sound an alarm and start the seal-off operation as well as starting up the center's air filtering system. All basic services are checked every day to assure they are operational.

In the event that SAC Headquarters were knocked out, however, each of SAC's three numbered Air Forces has its own similar command center. In addition, SAC presently is outfitting three KC-135 jet tankers so they can serve as flying command posts to direct operations in event of war.

The most vital command and control facilities are located at the lowest of the three levels in the underground center. Here, for example, is the 140 ft. long control room with its giant moveable panels that give the SAC Commander and his staff a complete display of the battle situation and deployment of forces. Emergency war plans, on panels that are hidden from view during peacetime operations, can be quickly rolled into position.

Closed Circuit TV

The SAC Commander and key members of his battle staff plus liaison officers can view the display panels from a double-decked row of glassed-in command rooms. By means of closed-circuit color television cameras and color TV receivers in the command rooms, the SAC battle staff can also view intelligence and/or global weather displays in nearby air intelligence and weather rooms.

This closed-circuit color TV system also enables key SAC officers, sitting in their above-ground offices in peacetime, to instantly be shown any of the situation display panels in the underground control room. This capability, coupled with the telephone and intercom facilities which connect above-ground offices with the underground control room, makes each of the above-ground offices a miniature command and control center from which decisions can be made and orders issued without the delay involved in walking down into the underground facility.

Adjoining the underground SAC battle staff command and control rooms is SAC's communications central which controls all of its vital radio and telephone facilities.

In the communications central is the "gold" phone which connects directly to the Joint Chiefs of Staff in Washington and the "red" phone which the SAC Commander, or an authorized deputy, would use to alert all SAC forces and to issue the emergency war plan order, if JCS so authorizes.

By means of master consoles, controllers can connect the SAC Com-

mander into any of the several hundred SAC telephone lines and/or its world-wide radio communications networks. (For details, see p. 132.)

In a matter of seconds the Commander can be talking directly with commanders of SAC numbered Air Forces or Air Divisions, SAC bases scattered around the globe, or to aircraft in flight, regardless of whether the Commander is sitting in the underground control room, upstairs in his peacetime office, in flight, or at home.

All important voice messages are instantly confirmed by teletype to prevent misunderstanding or doubt. Teletype has the advantage also of greater security because messages can be automatically encrypted.

Delivery System

Written messages from the control room are sent to the SAC teletype communications room, two levels above, by means of pneumatic tubes which zip them to their destination. An elaborate system of pneumatic message tubes is installed to permit rapid delivery of written messages between major facilities in the underground center.

Another important underground facility is SAC's global weather unit, operated by Military Air Transport Service personnel permanently assigned to SAC Headquarters. Weather information from U. S. and foreign civilian weather bureaus, plus military collection agencies, is channeled into this facility. With the aid of an IBM 704 computer, this unit prepares forecasts for periods 6 to 12 hr. in advance along each of the routes that SAC bombers would fly to reach their assigned targets.

IBM 704 Functions

The IBM 704 digital computer, located near the main control room on the lowest underground level, is used for a number of other important functions.

For example, computing estimated target damage from aircraft reports to determine whether a clean-up mission is necessary to knock-out vital installations, for computing revised flight plans due to unforeseen contingencies, and assisting the SAC Commander in efficient control of the force.

When the new SAC Control System (465-L) becomes operational, its large computer will take over all of these functions. (For additional details, see p. 132.)

Underground center also houses SAC's intelligence analysis activities which include photo and electromagnetic reconnaissance. Soon to be installed will be a new intelligence data handling system, consisting of a huge IBM 7090 digital computer with storage facilities for 32 million words. (See p. 134 for details.)

New Communication Systems

The deterrent effect of the Strategic Air Command's thermonuclear weapons carriers, the most awesome collection of military power the world has ever known, and their effectiveness in event of war, depend upon the speed and surety with which SAC can unleash these globally dispersed bombers and missiles. This in turn depends upon the speed and surety of SAC's communications by which it would transmit the "go-code."

To stretch the reaction time which has been so drastically compressed by the advent of ballistic missiles, SAC must now be able to perform in split seconds those vital command and control functions that formerly required hours.

Until fairly recently, a SAC commander who wanted to transmit a message to airborne bombers had to relay the message through the Airways and Air Communications Service, the Air Force's own "Bell System."

Today, using a newly installed "Short Order" single sideband system, a SAC commander can pick up a telephone in his office, his home, in a public pay phone booth, or a handset in his aircraft and usually within only a matter of seconds he can be talking directly with any of his aircraft anywhere around the globe.

Although SAC's new Short Order single sideband network is a vast improvement in both speed and reliability over previous communications, SAC is not content, nor can it be.

Present ground-air communications is by voice. Despite the use of brief prearranged code words, voice communications are not as secure as SAC would like. This is one reason why SAC is testing a high frequency data link which would employ the same Short Order SSB network but would transmit routine messages in digital form. This will permit automatic encrypting for greater security and be more resistant to possible enemy jamming.

Because high-frequency radio is inherently vulnerable to both natural and man-made interference and outages, SAC is eagerly pushing for the use of communication satellites which would provide global coverage, yet would operate in the Ultra-High-Frequency (UHF) band which is far less vulnerable to natural disturbance and enemy countermeasures.

SAC's great concern and effort for improving the speed, reliability and security of its vital command and control communications stems largely from the nature of its assigned role. But some of the impetus for keeping SAC's com-

TELETYPE communications room in underground command center handles messages which must be encrypted for secrecy and can not be transmitted by radio or telephone, as well as routine type messages. System of pneumatic tubes quickly carries messages to and from this room to all parts of SAC's underground command center.

Cut Reaction Time, Speed Control Function

munications abreast of the latest techniques undoubtedly stems from the fact that former SAC Commander Gen. Curtis LeMay, and the present Vice Commander, Lt. Gen. Francis H. Griswold, both are radio amateurs ("hams").

The nation's radio hams were among the first to try single sideband on a wide scale and found it far superior to conventional amplitude modulation (AM). LeMay and Griswold both got their first taste of SSB as radio hams and immediately spotted its implications for SAC's operations.

It is not surprising that Collins Radio, which got its start in the ham radio field and is one of the pioneers in single sideband, supplied the first such equipment which SAC tested, and that the company, and its subsidiary The Alpha Corp., supplied the Short Order system which SAC now uses.

SAC's need for reliable, fast communications is not limited to the ground-air type. Equally important are a number of point-to-point communications requirements, including:

- **Joint Chiefs of Staff,** from whom would come the order to unleash SAC's forces.
- **Primary Alerting System,** which enables the SAC Commander, or a deputy, to instantaneously reach every SAC base commander around the globe.
- **Norad tie-in,** which connects SAC Headquarters to the North American Air Defense Command in Colorado Springs, relaying information on enemy attacking forces obtained from early warning radars, such as the DEW Line and Ballistic Missile Early Warning System (AW May 30, p. 76).

For these critical point-to-point command and control functions, SAC uses both special facilities designed to its specialized needs by commercial telecommunications companies and its own facilities, such as another SAC single sideband network for point-to-point communications, known as the Commanders Net.

Every conceivable precaution is taken and back-up measure is provided to assure that these critical circuits are as invulnerable as ingenuity can make them to both intentional and accidental damage or disruption.

For example, within the U. S. where domestic telephone circuits are used, specially hardened cables and switching centers have been employed. In the Primary Alert System two circuits are continuously available between all key SAC bases and different geographic routes are used so that a single bomb can not take out both circuits. SAC can instantly preempt additional commercial trunk lines by prior arrangement with the telephone companies.

Whenever these critical circuits are not in use they are automatically being tested for continuity every three seconds. If circuit continuity is broken for three successive tests, covering a total elapsed time of nine seconds, an alarm is automatically sounded.

SAC has designed a great degree of flexibility and versatility into its communications system. For example, because propagation characteristics of high frequency radio used both for the Short Order and Commanders Net systems can vary sharply with time of day and latitude, and can be degraded by solar or magnetic storms, direct communication may not always be possible at any instant between two points.

Propagation Conditions

If SAC Headquarters wants to talk with a SAC base at Goose Bay, Labrador, for example, but propagation conditions between Omaha and Goose Bay are not good at that time, Headquarters may use a SAC base in Spain as a radio relay, permitting direct Omaha to Goose Bay conversations via the station in Spain.

If SAC Commander Gen. Thomas Power while in flight wants to talk to a SAC base commander and propagation conditions are such that his airborne SSB equipment can not get through to the desired base directly, Gen. Power can work through the air-ground Short Order system which is patched into the Commanders Net to provide point-to-point service to the intended base.

The Short Order system consists of four stations within the U. S. One is at Omaha, the others are located at each of SAC's three numbered Air Force headquarters: 2nd AF at Barksdale, AFB, La.; 8th AF at Westover AFB, Mass.; and the 15th AF at March AFB, Calif.

If SAC Headquarters wants to talk with one of its far ranging bombers, but can not reach it using the Omaha station because of propagation difficulties for this particular routing, a few twists of a telephone-type dial instantly connect Headquarters with one, two, or all three of the other Short Order stations via telephone landlines or other circuitry. Using this remote station's transmitter-receiver, Headquarters talks directly with the aircraft in the same manner as if it were using its local Short Order station.

For communications with aircraft operating in the polar region, where HF radio may be blacked out by the aurora or other atmospheric disturbance, SAC can use the Air Defense Command's circuits to the DEW Line and utilize UHF equipment at DEW Line sites to have information passed to aircraft.

MASTER CONSOLE at underground command center controls all of SAC's vital telephone and radio communications facilities required to alert all SAC forces and/or to issue the "go-code." Like all of SAC's vital communication facilities, the "Red Phone" handset (foreground), used to alert the forces, is installed in duplicate to assure reliability.

There are approximately 213,000 mi. of telephone and submarine cable lines that interconnect SAC Headquarters with about 83 different bases and facilities. SAC's telephone bill amounts to nearly $15 million annually. The Command also has use of 333,000 mi. of teletype circuits to 94 different locations. These are used for routine messages and to handle highly classified information which must be transmitted in encrypted form.

Short Order Details

Each of the four Short Order stations has a transmitter site and a receiver site which are separated by about 20 mi. to prevent mutual interference. Each transmitter site contains six 10 kw. single sideband transmitters and three 45 kw. units. The former are manually tunable by operators at the site, though normally operated at preselected frequencies. The 45 kw. transmitters can be tuned to any desired frequency by remote control from SAC Headquarters or from any one of the three numbered Air Force headquarters.

At each transmitter site there are a variety of antennas. One is a huge six-sided billboard type antenna, 200 ft. across, each of whose sides consists of a multiple broadband dipole arrangement in front of a reflector screen. To obtain any desired azimuth coverage, one or more sides of the billboard can be selected by remote control. The billboard antenna covers the frequency band of 9-27 mc. In addition there are six log-periodic wideband antennas, covering the frequency range of 6.5-60 mc. Each is mounted atop a 120 ft. high structure and can be rotated by remote control to any desired azimuth position. Finally, there are two omnidirectional antennas which jointly cover the band of 2-30 mc.

At each receiver site there are six remotely tunable receivers plus six transceivers which normally operate as receivers but can be used in the transmit mode if needed. A hexagon billboard antenna is installed at each site, plus four rotatable log-periodic antennas and one Wullenwebber antenna which jointly cover the 4-30 mc. band.

In the underground SAC Command Post at Omaha, and at each numbered AF headquarters, there are master control consoles, installed in duplicate, which can control and use facilities of the Headquarters station (actually some distance removed from Omaha for security from bomb blast) or at one or more of the other three stations in the Short Order system. By means of a telephone-type dial, an operator can select the station(s) he wants to use, the specific frequency, type antenna and azimuth coverage best suited for reaching the aircraft with which he wants to talk. Operator also can select upper or lower sideband or conventional AM type operation. By means of push buttons, operator can patch selected transmitter-receiver into any one, or several, incoming telephone lines at the console.

When an operator at one of the master consoles at a SAC Command Post dials his choice of frequency and azimuth coverage, a billboard antenna of the desired frequency range and azimuth orientation will be connected to the transmitter automatically. If, however, the desired billboard antenna is already in use, the system will automatically connect transmitter to one of the log-periodic antennas and rotate it to the requested azimuth position. (Operator hears short bursts of a 1,000 cycle tone until antenna is rotated to desired position.)

If all of the log-periodic antennas at the station should be in use, transmitter then is connected to an omnidirectional antenna. To let operator know that a lower-gain antenna is being used, a short burst of 1,000 cycle tone will sound at the console. If all antennas are in use, operator will hear a 60 impulse-per-minute tone.

System has been designed to give override or interrupt privileges to priority users. Naturally, SAC Headquarters has the top priority and can "seize" all transmitters at all four Short Order stations for a general alert broadcast.

Certain designated officers can dial predetermined digits and seize any single circuit for exclusive use, whether or not it is in use, and prevent entry by any other operator, except for a general alert seizure.

If an operator at one SAC base without such seizure priority hears an operator at another SAC base communicating with an aircraft with which he also wants to talk, the former can dial suitable digits and gain entry into the circuit. If, however, an operator wants to prevent entry by others (without priority), he can dial digits which prevent entry except by general alert seizure or priority user.

Built-In Priority

The system of automatic built-in priority is expected to work on Short Order because only a limited number of persons have access to the master consoles. However, for important telephone messages in and out of SAC Headquarters, a manual switchboard is used. Each call has an assigned priority and the female operators pre-empt circuits, if necessary, to give a higher priority call the circuits needed. For routine internal telephone calls where priorities are not employed, an automatic dial switching system is used.

SAC bombers and tankers communicate with Short Order stations using AN/ARC-58 sets, built by Collins Radio, and AN/ARC-65s built by Radio Corporation of America. The ARC-65 is a modified version of the older conventional AM type HF set, the ARC-21.

With the new Short Order system and existing UHF communications facilities, SAC's ability to establish radio contact with all of its airborne aircraft within five minutes is fast approaching 100% reliability, according to Lt. Col. J. H. Beler, chief of operations branch, Communications Electronics Division at SAC Headquarters. The Short Order system, the ARC-65, and the ARC-58 airborne equipment are an outgrowth of a SAC requirement with the development program assigned to Rome Air Development Center.

Other Improvements

Although SAC is extremely pleased with the vastly improved air-ground communications being obtained with Short Order, it has its eye on another improvement which shows promise of great pay-off. That is data link, using the Short Order system.

In addition to the fact that presently used voice communications inherently lack the security that SAC seeks, voice makes relatively inefficient use of the radio spectrum, at least for routine messages, compared to digital communications techniques, Col. H. L. Kannor points out. Kannor is chief of planning branch, Communications Electronics Division.

With the advent of the Strategic Air Command Control System (465-L), a digital data processing and display system, aircraft position and status reports received by voice radio would need to be converted into suitable digital format manually before they could be entered into the data processing system. This not only introduces time lags but also offers the possibility of human error.

With an HF radio data link, aircraft position reporting can be made automatically, with little or no effort by the bomber crew, and it can go directly into the SAC Control System, Kannor says.

Because of fading and other propagation difficulties, a reliable data link for operation in the HF band is considerably more difficult than in the UHF or VHF bands. However, SAC currently is running tests on an HF data link and the results to date are encouraging.

Col. Kannor also looks hopefully to the availability of communications satellites which could, as he puts it, "practically eliminate the mish-mash of overseas connections." Communications satellites also would open up the possibility of global television, a useful tool for SAC in transmitting photographs of bomb damage.

Intelligence Vital to SAC Counterpunch

"Fast, accurate collection, analysis and dissemination of information is as important to our deterrent force as missiles or bombers," in the view of Brig. Gen. Robert N. Smith, Director of Intelligence for the Strategic Air Command.

With the advent of the ballistic missile, the relatively comfortable two-hour warning of surprise attack provided by the DEW Line and its airborne extensions has been slashed to at most the 15-30 min. that can be provided when the Ballistic Missile Early Warning System (BMEWS) and Midas early warning satellites become operational.

The question of whether a U. S. President will make the irrevocable decision to launch SAC's ballistic missiles on the strength of a few faint signals of electromagnetic radiation detected by BMEWS radars and/or by Midas infrared sensors is one that history alone can answer and that a potential aggressor must ponder.

If, however, other indications of possible aggression can be obtained a few hours before an attack, and if they can be quickly and correctly analyzed to understand their implications, they could provide the necessary substantiation of electromagnetic evidence obtained from early warning systems such as BMEWS and Midas. Equally important, such early warning intelligence will enable SAC to get more bombers into the air and place more missiles on ready status.

Not only must the nation have such an extensive, quick-reaction intelligence capability, but potential aggressors should know that we have it because of its strong deterrent effect, Gen. Smith believes. If the advantage of surprise can be stripped from aggression, it loses much of its attractiveness.

Never before has a military organization had so formidable a task in the gathering, analysis and dissemination of intelligence information as SAC faces. Its area of intelligence interest covers most of the earth's land mass and is shrouded in secrecy.

Warning center information from all areas of the globe flows continuously into SAC Headquarters where it is monitored and analyzed by competent intelligence personnel and reduced to data readily usable by SAC for operational planning purposes.

In addition to early warning intelligence, SAC also needs information on its strategic targets and on enemy defenses, both of which are continuously changing. The former includes airfields, missile sites, industrial facilities and vital government and military nerve centers. Enemy air defense intelligence includes the location of early warning radars, anti-aircraft missiles, interceptor airfields and the performance characteristics of air defense weapons.

The advent of reconnaissance and early warning satellites, and the prospect of weapon-carrying satellites, already is focusing SAC's intelligence interest on the vast reaches of space. The National Space Surveillance Control Center at Bedford, Mass., operated by the Air Force under sponsorship of the Advanced Research Projects Agency to monitor all known space objects, is evidence of this interest.

In order to quickly extract maximum useful information from the vast amount of intelligence data that channels into SAC Headquarters here (an average of more than 13 million word-groups every month), SAC is radically altering its methods of analyzing intelligence information through the application of digital computers and other automatic data processing equipments. Representative of those now in use or scheduled for early installation are the:

• **Intelligence data processing** system: This system, scheduled for installation this summer, will employ a large, high-speed IBM 7090 digital computer with a storage capacity of 32 million words on 32 magnetic tape handlers. The system, being developed by International Business Machines Corp., will receive intelligence information from a variety of sources on a continuing live-input basis. The computer will seek to correlate this fresh intelligence with data already in its storage in an effort to spot significant enemy activity which may indicate impending attack. For example, each of a dozen overseas bases might report aerial reconnaissance by a single enemy aircraft, not in itself enough to arouse serious suspicions of any one base commander. No single report in itself would necessarily be cause for concern, but all fed into the computer at SAC Headquarters, and correlated with other data, might provide grounds for a general SAC alert. The intelligence data processing system to be installed at SAC Headquarters is expected to test the concept and it may be expanded to encompass the entire Air Force.

• **Minicard System:** Semi-automatic search and speedy access to the vast amount of intelligence information which has been accumulated will be possible soon, using the Minicard system, developed by Eastman Kodak under Rome Air Development Center sponsorship. (AW Aug. 6, 1956, p. 259.) Minicard also will provide roughly a 1,000:1 reduction in the amount of storage space required. It employs a small piece of film, 35 mm. wide by 16 mm. high, upon which can be recorded up to 12 pages of printed material and/or photographs. Along one edge of the film strip is recorded in binary form an index to the material contained on the strip. Several hundred such strips are stored on a metal "skewer". By placing a skewer of film strips into a search machine, coding the machine for the information sought, each strip will be scanned and those of interest will be extracted automatically. These can be viewed in an optical projector or reproduced in enlarged form. By late fall, SAC Headquarters hopes to have its Minicard system installed.

In addition to the foregoing, SAC Headquarters is using a number of recently developed semi-automatic devices to increase the speed and accuracy with which it can analyze aerial reconnaissance photographs. One of these, for example, is the Nistri stereo-comparator made by the O.M.I. Corp. of Rome, Italy. It plays an important role in enabling SAC to establish accurately the location of a target relative to a natural or man-made landmark.

If the landmark is some distance from the target, a series of photographs must be made, each overlapping slightly the adjoining one in coverage. The stereo-comparator enables an operator to quickly determine distance and bearing from a point on one photo to a point on another, to another, to still another until the photo containing the landmark is reached. The Italian machine has cut the time required for this operation by a factor of 15:1, with improved accuracy, compared to the previous manual method.

SAC also is using a device called Logotronic Printer, which enables it to obtain a great deal more significant detail from reconnaissance photographs made under adverse lighting conditions. The Logotronic Printer employs a cathode ray tube electron beam for making a contact print of the low-contrast negative, using a photo cell mounted behind the paper to automatically adjust the intensity of the electron beam for uniform contrast over the entire print. The use of an electron beam, with its tiny spot of illumination together with a photo cell which instantly adjusts the beam's intensity according to the darkness of the portion of the negative being printed at that instant, enables SAC to obtain details that otherwise would be lost.

As SAC makes the transition from bombers to ballistic missiles, the problem of hitting the target changes. There is no need for landmarks along

the route to guide the missile, but the target's precise location relative to the missile launch site must be known prior to launch. Here again, SAC leans heavily on digital computers for the considerable computation required to establish missile guidance system instructions.

SAC Headquarters has set up a Ballistic Trajectory Computing Center under the 544th Reconnaissance Technical Group, which also has four other intelligence elements: Target Center (for bomber and missile targets), Electronic Intelligence Center, Analysis Center and Data Center. A new wing is being constructed at SAC Headquarters to house the expanding activities of the Trajectory Center.

Trajectory computations presently are being performed on the underground IBM 704 but these might become a job for the SAC Control System (465-L), when it is installed.

Once the target has been established, and its position determined relative to its own national geodetic datum, and the same has been done for our own missile sites, then the two geodetic data must be correlated to establish the relative bearing and distance from launch site to target. This is an involved computation which must take into account the size, shape and mass of the earth and its gravity field gradient. Additionally, to compute the required missile trajectory, the effects of atmospheric density, pressure and temperature must be taken into account.

Once the guidance parameters which will be inserted in the missile's command or inertial guidance system have been computed for a specific launch site and target, they are verified by working the problem a second time, but in the reverse direction. That is, given a missile with characteristics of the one installed at the particular launch site, if the calculated guidance instructions are inserted, where would such a missile impact?

Basic techniques for computing guidance settings and trajectories are checked out, using missiles fired from the Atlantic and Pacific Missile Test Ranges.

Once the missile guidance settings have been computed and verified, they are printed by the computer in the format in which they will be used at the missile site and reproduced by a photographic process to avoid possible human error if the computer output had to be retyped. The guidance setting sheets are then plasticized so that the values cannot be altered.

SAC's most complex automatic data processing system, known as the SAC Control System (465-L), is intended to provide Headquarters, and commanders of the numbered Air Forces, with instantaneous information on the status of SAC's global forces. Although not a direct part of SAC's intelligence effort, it will be used for related activities.

The 465-L system, being developed by International Electric Corp., will give SAC's commander at Headquarters, and commanders at each of the numbered Air Force headquarters, an up-to-the-minute report on the status of SAC's bomber and missile forces. System will display such things as:

- **Number of aircraft in the air,** their locations, amount of fuel each has and which of its assigned targets it can reach with present fuel load.
- **Number of missiles** on ready status.
- **Number of aircraft and missiles** undergoing maintenance and time required to place them on ready status or get bombers airborne.
- **Availability of crews** to man bombers.

In the event of the outbreak of war, the SAC Control System will be used to provide commanders with information which will enable them to quickly evaluate the battle situation, altering previous plans as needed to cope with the unexpected. As individual SAC bombers are refueled, this information will be radioed in and entered into the 465-L computers. By means of periodic radio reports and dead reckoning estimates, the system will be able to show approximate position of each SAC bomber to allow certain last-minute changes in assigned target if necessary.

Radio Information

As each bomber drops its bombs, it will radio information on the success of its mission in terms of estimated miss-distance to enable the 465-L system computers to calculate probable degree of target destruction and/or destruction of other than the original assigned target if release point was not as planned.

In addition to these types of live (real-time) problems, the 465-L system computers also will be used for a variety of other calculations currently being performed here on an IBM 704 digital computer. These include:

- **Target aiming point:** Calculation of the optimum release point for a nuclear weapon in order to achieve maximum destruction of critical targets with minimum number of weapons.
- **Flight planning:** Calculation of routes and timing for SAC bomber penetrations to assure safe separation between aircraft while en route and over targets.
- **Weather forecasting:** Using available weather information, computer will forecast conditions along penetration routes and in theater of operation.
- **War gaming:** Computers can be employed for war games to test effectiveness of SAC war plans.
- **Missile trajectories:** Computation of required guidance instructions for SAC ballistic missiles.

Heart of the new SAC Control System will be four huge solid-state digital computers, one installed at Headquarters and one at each of the three numbered Air Force headquarters. The computers will be the AN/FSQ-7A, originally developed by International Business Machines Corp. for use in the SAGE super-combat centers.

Each of the four computers will have the capacity for handling the entire system computation function and all four will be suitably interconnected by dual landline circuits so that any one can serve all four command centers in an emergency.

Under normal conditions, one of the four FSQ-7A computers will be in use; a second will be performing the same computations as a backup, but will be "off-line." The third will be used for non-real-time functions, such as computing missile trajectories or flight planning, and the fourth will be undergoing preventive maintenance.

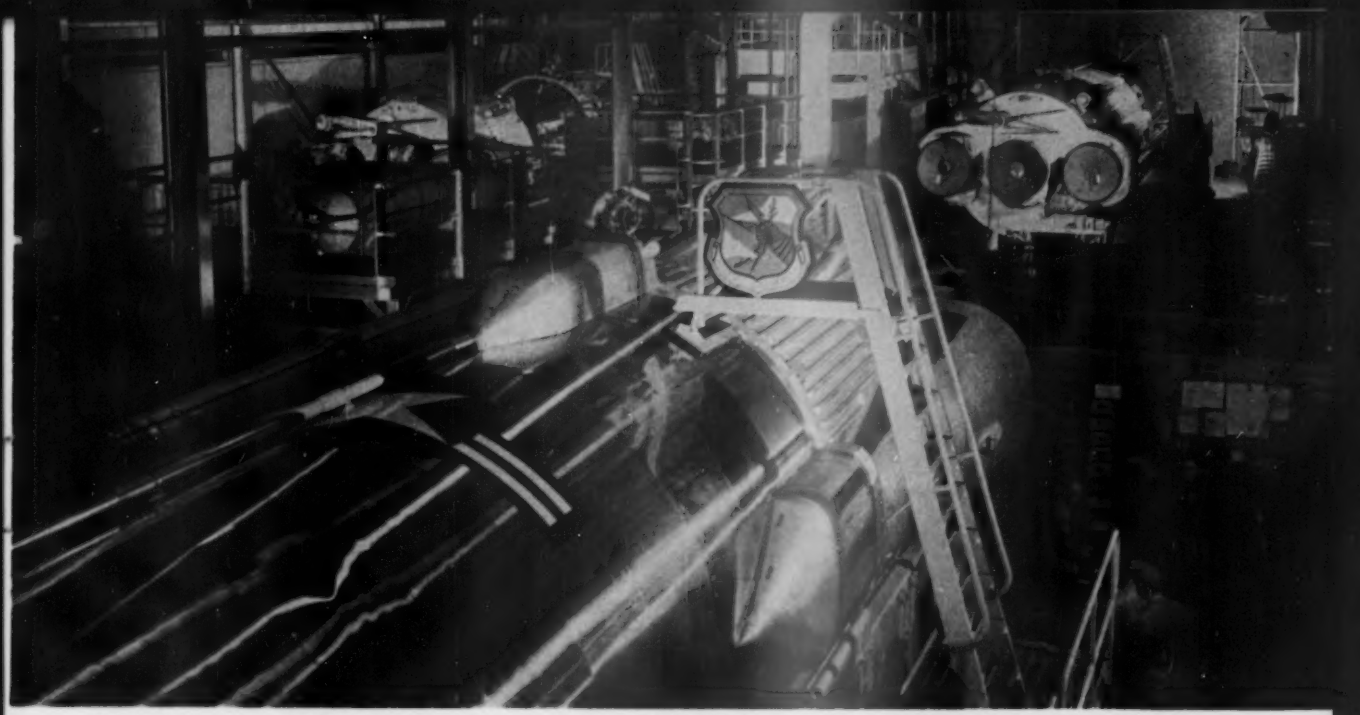
Any one of the four computers will be able to "talk" directly with any or all of the others to obtain or transfer information. When interconnecting circuits between computers are functioning properly, an extremely fast data-transfer rate will be employed. However, the system will automatically lower data rate if circuit performance is degraded.

Information on the status of missiles and aircraft at SAC's many bases will be fed into the 465-L system computers by means of push-button communication consoles at each base, connected by radio, landlines and/or submarine cable. Until a reliable high frequency radio data link is developed, reports from individual SAC airborne bombers and tankers will be received by voice and entered into the system by human operators.

In addition to providing SAC Headquarters and the three numbered Air Forces with up-to-the-minute information on the status of the distant forces, the SAC Control System also provides means for instantly transmitting commands back to each of the remote bases.

A prototype installation of the SAC Control System will be set up by International Electric Corp., a division of International Telephone & Telegraph Corp., in Paramus, N. J. to try out the basic system concepts and design. Tests of the prototype installation at Paramus are scheduled to begin early next year.

Although SAC is justifiably concerned over the number and quality of its weapon systems, it is showing increasing awareness that these systems by themselves are only of marginal value without fast, reliable communications and information gathering, analysis and display. This is why SAC is going all-out for automatic data processing and display systems.



ATLAS intercontinental ballistic missiles undergo acceptance checks in missile assembly building at Vandenberg AFB, Calif.

ICBMs Add Complexity to SAC Logistics

Strategic Air Command's logistics system, preparing to support complex new missiles and aircraft, faces conflicting demands of instant readiness and swift strike tactics on which no price tag can be hung and at the same time an austere defense budget from which it must wring the most efficient use.

Logistics is the most pragmatic side of SAC's transition and is deeply entwined in relationships with the Air Research and Development Command and Air Materiel Command in weapon system conception, development and procurement.

SAC logistics functions fundamentally in the traditional military mold: operations lays down the task and logistic must support it.

But SAC operations cannot ignore the support requirements of increasingly sophisticated systems in framing its tasks.

Gen. Thomas Power's request for an airborne alert is a case in point. SAC has the basic hardware to mount such an operation but not the spares. Lead time to fill the shelves is a major problem, Gen. Power points out. Except for fuel, Gen. Power said, no more funds would be necessary over the long pull since purchase of spares would be compressed into a shorter period, but not increased in total.

SAC's most distinctively different logistics problem in an era of increasing technical complexity is the support of liquid propellant intercontinental ballistic missiles now entering the inventory and the solid propellant ICBM Minuteman expected in service in initial phases in 1962.

An example of how SAC logistics has already influenced this area is the decision to locate Atlas and Titan ICBM launch complexes near existing SAC bases.

Locating these sites in remote areas was recommended to provide greater dispersal of targets for an enemy. SAC, on the other hand, was concerned with practical support details such as provision of housing for site personnel and the advantages of drawing on various usable facilities at existing air bases, such as welding and paint shops and the like, even though essentials as blockhouses and launching areas obviously have to be constructed specially.

For this reason, and others such as integration of missiles into the command organization, these sites will be located near existing bases.

Three Trends Evident

Three trends are evident in SAC's logistic response to a chang...g technology and at least two of them are partly concerned with demands of tighter budget control and more complex and expensive equipment.

- **Electronic data processing** inventory control expansion.
- **Adaptation** of maintenance and supply practices to new aircraft as the Convair B-58 and to missiles.
- **Earlier SAC** participation in development phases.

Inventory control has become a key problem to SAC, partly because of the increasing number of Category I "Hi Valu" parts, because of tighter budgets, and because of congressional criticism of so-called procurement "waste."

Costs of "Hi Valu" spares for the Convair B-58 are one reason why this aircraft will not be used in Reflex operations under present planning, although it would be feasible logistically to Reflex the aircraft—with perhaps a two-year lead time on spares.

One specific example of the Reflex problem with this airplane is that, because of its extensive avionic equipment, if there is any power on in the airplane its air conditioning system must be operating. To prevent rapid wear on this system, a ground unit would have to accompany the aircraft on Reflex, multiplying cost and transportation problems.

SAC inventories are currently held at minimum level, though they are sufficiently large for an emergency on the basis of requirements indicated by the constant war gaming exercises which SAC performs.

An indication of how critical this problem could be can be drawn from airline experience. United Airline's President W. A. Patterson noted in a speech recently that airlines have had many spares inventory shortage problems in introducing jets, even after extensive test programs had provided ex-

perience for judging spares life. If this problem has been a headache for commercial airlines, Patterson noted, how much tougher is it for the military where mistakes could mean national catastrophe?

Over-all Air Force policy calls for concentrating management attention on spares that are both critical to operations and in unit cost. Spares are classed as Hi Valu or Category I, Category II, and Category III or essentially bench items where quantities bought may be very high but unit costs are no higher than $10 and probably much lower.

Boards which include representatives of using commands meet periodically on various weapon systems and formulate lists of Hi Valu spares, and may limit them in respect to maximum inventory and require special handling requirements in the interests of speed and prevention of damage.

This becomes the other side of the coin opposite operations requirements which SAC logistics must resolve.

As a step to meet its inventory problem SAC has International Business Machines 305 RAMAC equipment installed at 19 bases and plans to have it at all SAC bases as well as tenant bases and some overseas bases by next spring. Base supply inventories within the command are valued at more than $800 million, the average base carries 50,000 items of stock, and 45,000 transactions valued at $2.3 million occur monthly. Management of this activity thus has become a prime concern.

At SAC's Offutt AFB base supply, a part available in base inventory is delivered to the flight line 25 to 54 min. after request, depending on priority. Other SAC bases have shown improvements in parts delivery, especially on lower priority spares where as much as two hours have been cut from request-to-delivery times. Support effectiveness has increased 10-20% with introduction of electronic data processing.

How System Works

As the system operates now for aircraft maintenance, the line mechanic calls in the part or stock number to base supply. After determining whether the item is on the machine, a card is punched and run through the machine which:

- **Prints out** the warehouse location if the part is available in base inventory and automatically recomputes the stock level following the transaction.
- **Searches out** and prints data for an interchangeable part or parts if the requested part is not available.
- **Flashes** a warning card if funding for a particular part is in question.
- **Automatically requisitions** a part from the proper depot if it is not available on base. The requisition is transmitted by transceiver to the depot. On priority items, AMC's Logair transport system can make rapid delivery.

Austere budgets and the need to keep inventories at minimum levels emphasize the value of electronic data processing, which maintains budget records on the machine for monthly and quarterly readout. Transaction records provide absolutely current requirements data and promptly note any change in requirements. Each time the requirements factors are changed, the data processing system checks for stock excesses, either on hand or due, permitting timely cancellation of parts due or return to the depot of excess on hand for use at other bases.

On the support side, stock levels are quickly responsive to demand rates, and coupled with immediate requisitioning, fewer unsatisfied maintenance requirements result. Operational readiness is increased by reduced cannibalization and fewer maintenance delays.

Storage capacity of the machine—76,000 line items—is considered adequate for base supply, but greater machine speed is being sought by SAC. Equipment, maintained by IBM personnel based at local company offices, is leased on a shift and a half basis and overtime is charged if more time is required. Reflecting the always growing awareness of cost consciousness, faster machine operation is needed to get necessary work done in the allotted lease time.

Category I and II spares are handled in this system. Category III—bench items such as nuts and bolts—are listed on punch cards and automatically reordered by machine on a monthly replenishment day unless specific instructions to the contrary, based on a warehouse check, are received. SAC finds it is cheaper to reorder systematically and possibly incur a surplus of such small items rather than have to specially order them.

Missile electronic data processing support will operate on a somewhat different basis.

Instead of a data processing machine at each missile base, the base will be tied in by transceiver, like that used at aircraft bases now for requisitioning parts not in base supply from depots, to the central missile supply depot at the San Bernardino Air Materiel Area. San Bernardino will have an IBM 705 with more storage capacity for functioning not only as site supply center but also as a depot.

As it stands now, SAC logistics people see some mitigating factors in spares inventory requirements for missiles:

- **Missiles** are basically simpler than the B-52 with all its equipment and will be exercised less or in less demanding fashion.
- **Environmental testing** has been the focus of large amounts of spending, and SAC expects it to pay off in greater reliability and more exact prediction of spares requirements.
- **Progessive inspection** will be followed, fixing to some extent in advance the subsystems where spares may be required. Some flexibility may also be gained by deciding how much missile down time will be permitted.

Enough black boxes will be provisioned at the site to keep the missile operational. But experience will still be necessary to determine many missile requirements. How often a liquid propellant missile will stand rapid propellant loading is one question, for example, and data on this aspect is being obtained at Vandenberg AFB through double propellant loading drills.

Missile Spares

Operational concepts will be a major factor also. If the missile is exercised frequently, the guidance system will be running more and will need more frequent maintenance inspection.

SAC is looking with interest at solid state electronics, which may offer opportunity for relatively inexpensive quick change modules, but it also feels it must retain its capability for bench repairs from a cost factor.

Deterioration of a missile in a fully hardened site is not regarded as a severe problem since there will be a controlled environment. However, missiles on sites will probably be removed and utilized for training firings at Vandenberg as a means for testing the effect of time on readiness and reliability. Such vehicles might well be adapted for Midas reconnaissance boosters.

On the basis of present experience, spares inventory of the newer systems—the B-58 Hustler supersonic bomber and the ICBMs—will be smaller than for the B-47 or the B-52. Partly this is because of high unit costs, as in the B-58, or because the weapon may be exercised less in the case of missiles.

This will have major implications for contractors, who have found spares a steady source of business, often long after the weapon has gone out of production. As a system of associate contractors begins to replace the prime contractor manager the division of spares business may undergo further change.

Present plans, for example, call for establishment at missile sites of a nose cone contractor team to which the nose cone will be shipped for final checkout and mating to the booster. Greater contractor participation closer to operation levels may become a trend.

SAC has amassed a fairly large degree of experience on new weapon systems and their support requirements through Air Force emphasis on earlier user command participation in research and development programs.

ALERT CREWS average 70 hr. duty time per week, and undergo many personal hardships to give SAC its rapid response capability.

SAC Manpower Policies Stress Quality

Transition of Strategic Air Command from a conventional manned bomber force to a mixed force of manned and unmanned weapon systems is predicated upon an adequate and stable supply of professionally qualified manpower to operate, maintain and support these systems. How to obtain and then retain this manpower today is a SAC problem.

For SAC, charged with primary responsibility for implementing national defense policies of deterrence and containment, it is a problem of quality rather than quantity.

Personnel turnover in SAC, while considerably less in most categories than Air Force-wide averages, nevertheless is sufficient to reduce measurably the operational capabilities of the Command, by lowering the experience level in combat units and by requiring more men and time to accomplish the same amount of work. Undermanned missile sites and nuclear bombers and tankers manned by crews on trainee status constitute no threat to a potential aggressor.

Technological advances of the past decade complicate the SAC manpower problem. Warning time preceding an enemy attack and reaction time in which to launch a counterattack—fundamental to our strategy of deterrence—have been compressed into a period of one or two hours, and will be further compressed to a period of 10-15 min. as enemy missile capabilities rise. SAC's effective retaliatory force will be limited to its manpower already on station, and by the competence of that manpower to perform assigned missions.

Personnel are leaving the Strategic Air Command today for two principal reasons, according to SAC personnel specialists. These are the attraction of better career opportunities for technical people in private industry and the repulsion of certain living and working conditions associated with a military career. The latter cause is aggravated by the requirements imposed upon SAC personnel through its cold war alert and force dispersal responsibilities.

SAC is currently manned by approximately 36,800 officers (28% of USAF total), 204,000 airmen and over 25,000 civilian employes. This force, largely composed of highly trained and technically competent personnel, operates from more than 45 bases in the U.S. and more than 20 overseas bases, stretching from Greenland to Puerto Rico, and from Guam to Spain.

Although SAC is currently losing three out of every four newly-commissioned non-rated officers entering active duty, it has made important gains in raising the professional standards of its officers by retaining only highly skilled and motivated personnel. This upgrading in quality makes possible reductions in the quantity of manpower required to perform specific assignments.

Most of the Command's officer losses

OPEN ROAD project reduces takeoff interval of Boeing B-47s to 15 sec. In one test, six KC-97s were airborne in 59 sec.

are among Date of Separation (non-career) officers. In this group are included many of the Command's doctors, lawyers and dentists, a "floating population" whose loss constitutes SAC's most serious officer personnel problem. In order to stabilize this group, SAC has long sought a 4-yr. minimum tour for all of its non-rated officer personnel. This has recently been approved in Washington, and becomes effective for college juniors as of Jan. 1, 1961.

Fortunately for SAC and for the nation, rated personnel retention rate is improving. In 1958 the Command flushed the 3-yr. tour for rated non-career officers after realizing that too many were leaving service just as they became combat ready. A 5-yr. minimum tour, which became mandatory for rated officers, already has resulted in an important increase in the number of combat-ready SAC crews, thereby increasing the combat capability of the Command. Today SAC is able to retain 45% of its rated personnel.

In another move designed to preclude repeated expense in time and money for training aircrew personnel (see box, p. 140), 233 pilots and navigators were recently recalled to active duty, representing a $45 million investment return to the Command. SAC hopes to recall men in other career fields, particularly non-rated officers in specialized technical fields, and current indications are that the Air Staff is supporting this proposal to a limited degree.

The Command has initiated a "Self-Help" program to cross-train crew members into other critical skill fields, such as aircraft and missile maintenance, communications, supply and installations. The program, called "Project Changeover" by the Air Force, has already resulted in filling many vacancies in these fields.

Transition to missiles has created another manpower problem in the Command. Many rated officers are reluctant to be reassigned to missile units because of the difficulties encountered in maintaining flight proficiency. Those who cannot maintain proficiency are subject to prompt suspension from flying status, an action that results in an immediate and substantial reduction in pay for those affected. As more missiles enter the SAC inventory and more missile units are formed, it is likely that this problem will become more acute and will result in some rated officers leaving the Command. SAC plans the same proportion of rated and non-rated officers in its missile force as exists in the manned aircraft force and places no restrictions on its unit commanders; they may be rated or nonrated.

SAC does not want young rated officers in its missile force until after they have completed a tour of flying duty and have made a reasonable return to the Command for the high training investment each man represents. In seeking to extend the minimum tour for non-rated officers to four years, the Command is again attempting to take advantage of the extensive missile training these men have received.

Airman retention within the Command differs from the officer retention problem in several important areas. In 1954 only 25% of SAC airmen were professional careerists. Today the overall rate of airman retention is 65%. Several factors contributed to this remarkable increase, which has resulted in a surplus of career airmen in most of the non-critical fields.

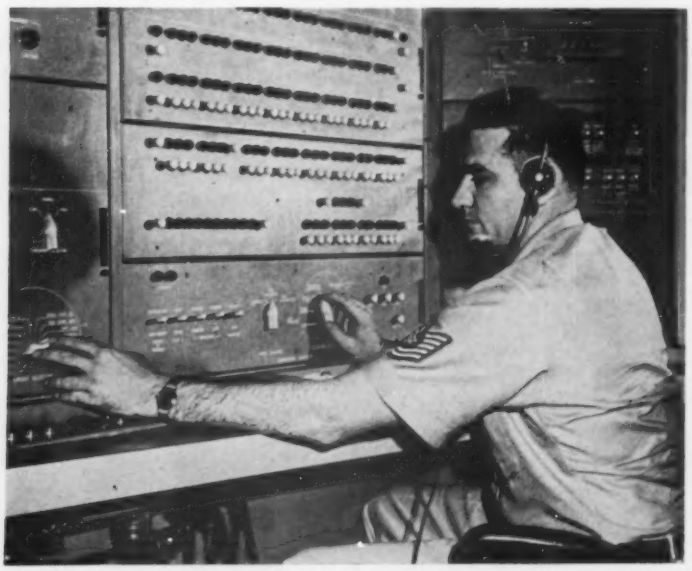
Airman re-enlistment rates began to climb from a low of 14% with enactment of the Career Incentive Act of 1955, which included a pay increase for airmen among other incentives. The Cordiner Committee, formed in 1956 to examine military personnel problems, published its report in 1957 and found re-enlistments both too low and severely imbalanced among airman career fields. The report led to enactment of the Military Pay Bill of 1958, which again raised military pay, and to improved military housing, medicare, survivors' benefits and the creation of the two airman super grades.

Internal support for higher airman re-enlistments came in the form of new Air Force policies which increased non-commissioned officer responsibilities and prestige and created dependent's assistance centers, more recreational facilities and in-service educational opportunities, and a vigorous career counseling program.

A new airman career plan—the 55/45 Program—has been initiated by the Air Force to obtain a desired airman balance of 55% career and 45% first term men.

Based on anticipated skill requirements, re-enlistment habits and manpower and money ceilings, the plan seeks to achieve this balance by means of quality control, selective recruiting and stringent re-enlistment criteria for all first-term airmen.

Surplus airmen in non-critical career fields create promotion freezes in these fields which affect all airmen, since non-commissioned officer strength is limited to a rigid proportion of the airman force by the Department of Defense. The number of available airman promotions started to decline in 1955 and



DIGITAL computer analyst checks his electronic equipment while exercise analyst at right collects data from tapes which spin throughout countdown. Controls monitor operation of integrated guidance system installed in Atlas equipment pod.

reached a serious low in 1959, prompting many highly skilled airmen to leave the service rather than accept such poor promotion opportunities.

Faced with markedly reduced requirements for lesser skilled airmen, and with greater specialties and responsibilities creating a need for more officers and fewer airmen within the Command, SAC has begun transitioning surplus airmen into the critical fields of guided missiles, intelligence, atomic weapons, and radar maintenance. Increased industrial, professional and service contracting, together with the introduction of electronic computing and data processing equipment, has further reduced SAC's airman requirements. Without controls, SAC could have a 70% career airman force by 1962, with the imbalance and lack of normal career progression that such a ratio would imply.

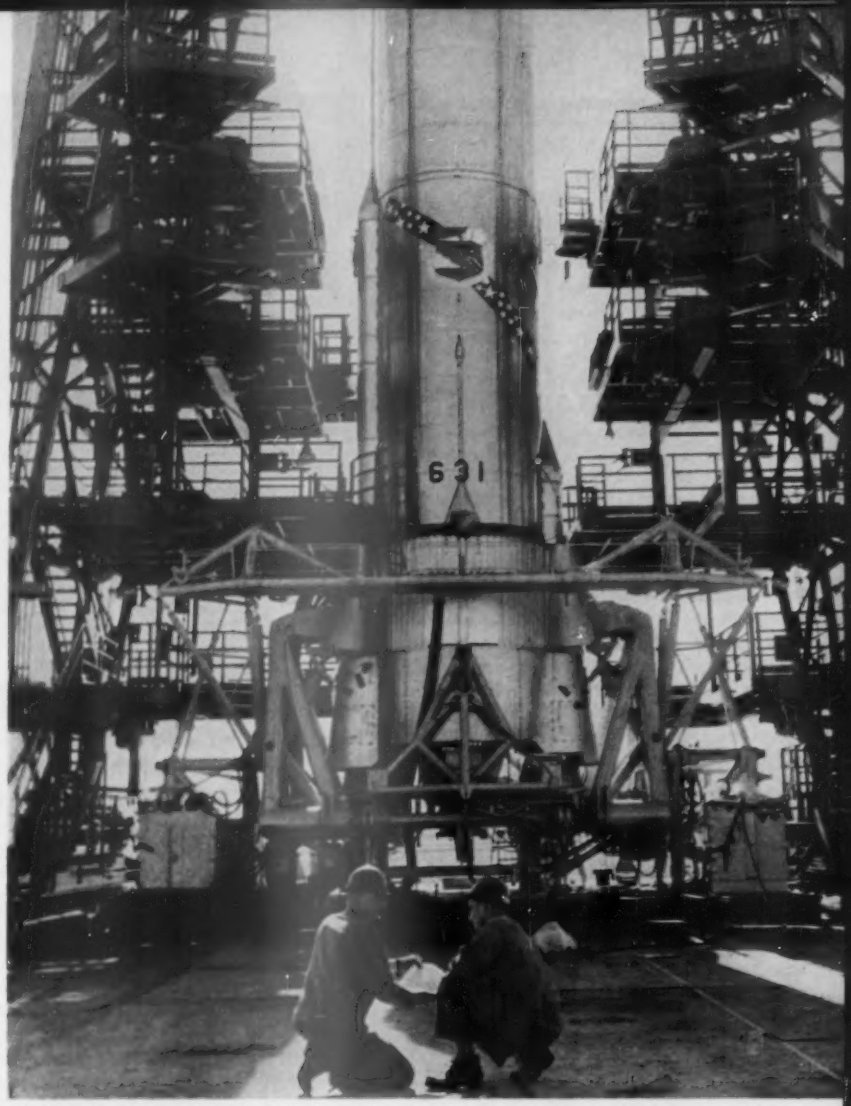
Critical Retention Areas

The two most critical airmen retention fields within the Command are the Electronics and Mechanical and Repair groups. In the Electronics group SAC needs a 62% ratio of career personnel. From July to December 1959 the over-all re-enlistment rate for first term airmen in this field was 30.4%. In Jan. 1960 the rate was 16%; in February, 18.1%. Rate of retention during the same period for first term airmen in the Mechanical and Repair group was 29.4%, considerably below the desired level. Reason for the lower airmen retention rate experienced during the first two months of 1960 was the USAF decision to withdraw certain incentives, such as re-enlistment for overseas, for a technical school or for a stateside base of choice.

Retention of airmen crew chiefs has also fallen below desired levels, with the Command presently retaining only 18.8% of flight and 19.9% of ground crew chiefs. The reduced requirement for rated enlisted personnel in SAC is indicated by the difference between the composition of flight crews. SAC's B-36s carried seven airmen crewmembers; the B-52s carry only one.

Stability and professionalism, according to General Thomas S. Power, SAC commander in chief, are essential manpower prerequisites to the accomplishment of SAC's missions: in peacetime, to maintain a force capable of deterring Communist aggression; in wartime, to destroy the Communist war-making capability.

"The field of personnel," Gen. Power has stated, "is one of the areas where we can do more for our defense posture than possibly in any other area." In order to obtain the professional force needed to operate SAC's global communications, reconnaissance, intelligence and support systems, in addition to a strike force composed of 450 B-52s, 1,500 B-47s, 300 KC-135s, 700 KC-97s and its operational ballistic missile units, Gen. Power has urged Congress to implement the following six-point program:



MISSILE launch crew formerly trained at Convair Astronautics plant in San Diego, Calif. Training is now conducted in USAF schools; crews get launch experience at Vandenberg.

• **Responsibility Pay**—Authorized by the 1958 Military Pay Act, this legislation, which would grant monthly payments of from $50 to $150 to officers whose positions involve unusual or critical responsibilities, has not been implemented. Estimated cost of the program for one fiscal year within SAC would be $2,380,000, 81% of which would be assigned to combat crew members, with the remainder going to other tactical unit personnel. Legislation, which needs the approval of the DOD, Budget Bureau and the President, has little chance of passing this year. SAC has made similar recommendations for missile force personnel, but there has been no action on this proposal to date.

• **Deterrent Duty Compensation**—Gen. Power wants to give his alert force crews $10 for every 24 hr. they are on alert, in recognition of the inconveniences endured by these crews, who currently average 70 hr. of duty each week. Gen. Power feels that some recognition is needed to neutralize the continuous personal hardships of forced family separation and to maintain the high morale of his combat crews. Estimated cost of this program would average about $11 million per fiscal year. Training cost for one B-52 aircraft commander amounts to $1,390,000.

Alert crews eat, sleep and live together while on duty in an area restricted to alert facilities located near the flight line. The image of crew members playing with their children on the concrete steps in front of the alert barracks instead of in the living room of their home is not overdrawn. The average crew member would gain only $700 per year from this proposal. Should SAC's airborne alert plan be implemented, the average alert crew duty week could be reduced to 55 hr.

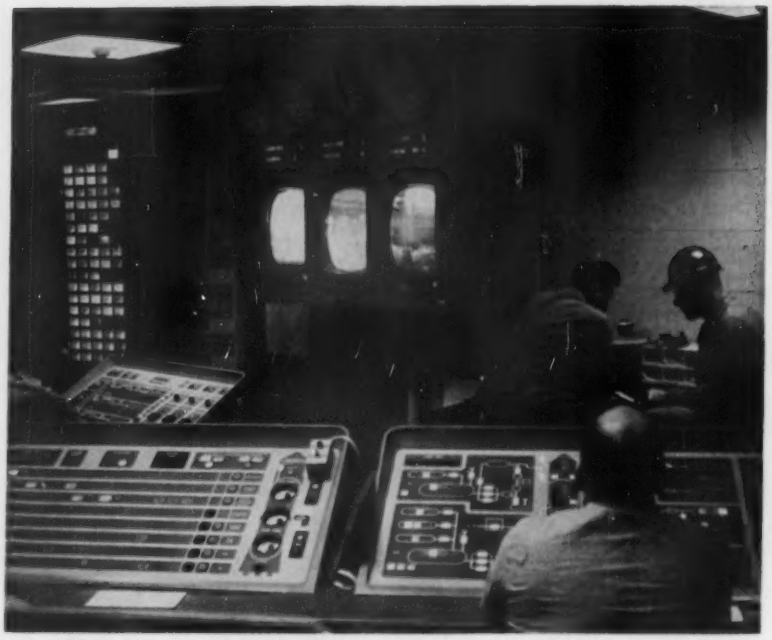
• **Spot Promotions**—Gen. Power has

proposed a revision of the present authority for spot promotions to reflect the change in grade structure of combat crews. The requirements and responsibilities of combat crew members have increased drastically since the Korean War, when B-29s were manned largely by captains and lieutenants. Spot promotions, which are temporary one-grade advances in rank, depend upon a crew's ability as a unit rather than upon individual ability.

The last major allocation of spot promotions was made in 1954 when SAC was authorized 785 promotions in all officer grades. With the exception of an allocation of 65 captaincies received in February 1959, no further authorization was made, despite the fact that the combat ready force quadrupled in size to 8,757 members. Only 9% of this number are presently covered by current spot promotion allocations. But last December Air Force Headquarters advised that SAC should begin to plan for possible termination of the entire spot promotion program. Gen. Power feels modification of the Officer Grade Limitation Act is necessary to increase officer grade ceilings.

• **Accrual Flight Pay**—Under this proposal, rated officers would be credited with a percentage of flying pay based on the number of years of rated service, on a graduated scale up to 100% for 20 yrs. Rated personnel assigned missile duties have found it difficult to maintain flight proficiency and are requesting reassignment to combat crew status in considerable numbers. To remedy the impact on morale caused by the loss of flight pay without cause and to prevent another instability factor from affecting SAC's capabilities, Gen. Power has played a prominent role in efforts to gain approval for this plan.

• **Housing**—Of approximately 113,000 families in SAC only 58,000 have adequate housing. In addition, current programing restrictions prevent SAC airmen in the lower three grades from being considered for any housing assistance. The lack of sufficient housing limits SAC's deterrent capabilities as much as would a lack of aircraft or runways. Rapid assembly of the nation's nuclear retaliatory force is an operational requirement. SAC personnel must be available immediately and their housing must be adjacent to the bomber bases or missile launch areas to which they are assigned before the Command can achieve a maximum alert posture. Gen. Power has asked for greater implementation of the Capehart Act to secure more liberal DOD programing criteria for family housing, and to provide housing for married airmen in the lower grades, many of whom are highly educated and technically competent specialists who "can't be kept if they can't be housed."



OPERATOR at left manipulates battery of television cameras in Atlas blockhouse. Cameras keep all three launching pads in the area under constant surveillance.

• **Proficiency Pay**—Designed to reward technically competent airmen in critical skill fields, SAC has objected only to the slender implementation of the 1958 law and not to the legislation itself. Under this law, SAC is authorized to pay from $50 to $150 per month to airmen holding one of three proficiency ratings. Thus far the Command has been authorized to pay only $30 per month for the lowest of these ratings, and an airman must be an Airman First Class or higher and be on his second or subsequent enlistment to qualify for the extra pay. The weakness of this implementation can be clearly seen in the case of an electronic technician, who can presently earn only $1 a day more than an assistant cook.

The career attractiveness program outlined above would not, in the opinion of Gen. Power, result in additional budget burdens. If the program were implemented, he has stated, it could result in lower taxes and decreased defense costs through creation of the stable professional personnel force for which it was designed.

In return for SAC's 20% share of current defense appropriations, Gen. Power said that the Command's resources "provide the capability for delivering 90% of the nuclear striking power of the free world, as measured in TNT equivalents." He said that SAC assets represent, in terms of total DOD resources, about 10% of the aircraft, 7% of the personnel, and 9% of the real estate and property values.

Viewed on this scale, and contrasted with the over $200 million spent by the Air Force in modifying the B-52 alone, the total cost of Gen. Power's proposals to stabilize the personnel of his Command may well represent an important economy.

SAC's quality manpower problem will prevail, it appears, to the direct detriment of our national interests, as long as military men are lured from service by more attractive careers in private industry, or simply by frustration and disgust with the insufficient rewards, balanced against their technical competence, of the military career itself.

Combat Crew Training Costs

Includes ATC and SAC training, pro rated cost of aircraft, maintenance of aircraft.

	B-52	B-47	KC-135
Aircraft Commander	$1,289,930	$489,410	$372,190
Copilot	253,150	139,900	105,320
Navigator	238,260	232,240	91,230
Radar Navigator	418,780	.....	.....
Electronic Warfare Officers	82,430	.....	.....
Gunner	46,880	.....	.....
Boom Operator	.....	.....	45,360
Total Crew	$2,229,430	$861,550	$614,100

DISASTER Control Teams at scene of C-124 Globemaster crash at Barksdale AFB, La., demonstrated effectiveness of SAC procedures to cope with incidents involving nuclear weapons. Weapons carried were unarmed, eliminating possibility of radiation hazard.

SAC Teams Control Nuclear Incidents

Strategic Air Command policy of aligning its nuclear bomber force in a combat ready configuration at all times implies an additional SAC responsibility for safeguarding not only its bases but also U.S. cities and towns against potential hazards associated with accidents involving SAC's nuclear weapons.

Disaster control programs have been formulated by USAF since its inception, but new techniques are required to control nuclear weapons. SAC, the prime U.S. military user of nuclear weapons, has developed of necessity the most experience in the use and control of these weapons.

First nuclear disaster control directives were formalized by SAC in 1953, and a firm disaster control program came into existence the following year. Today Disaster Control Teams have been established at SAC Headquarters and at each SAC numbered Air Force, in addition to smaller teams located at every SAC base throughout the world.

Specific objective of SAC's disaster control operation is to minimize the effect of a nuclear disaster on the immediate operational capability of the strike force and to restore the operational capability of the base or unit affected as soon as possible following an attack or accident. The disaster control operation consists of three phases to accomplish this objective.

- **Discovery and notification**—Includes verifying initial disaster report, alerting responsible agencies, activating Disaster Control Teams and notifying higher headquarters.
- **Containment**—Includes emergency actions to secure the disaster area, evacuation of non-essential personnel, rescue and medical treatment of casualties, prevention of further personnel or facility damage from detonation of explosives, and assessment of possible immediate radiation or other toxic hazards.
- **Clean-up and recovery**—Includes recovery of weapon system components, removal of debris, decontamination of areas and material, repair of damaged facilities, and environmental sampling and analysis. Should the incident involve an act of aggression, these efforts are directed primarily at recovering and launching SAC's retaliatory forces.

Authority and coordination, vital to the success of any disaster control program, have been carefully defined in SAC regulations establishing the Command's disaster control plan. Pre-attack planning, attack and post-attack actions designed to restore operational capability, and emergency actions to cope with peacetime nuclear accidents have provided SAC, said Col. Alvin F. Meyer, Jr., "with a high degree of capability in dealing with nuclear weapons accidents and other disaster situations involving nuclear materials."

Col. Meyer, a senior industrial hygiene engineer in the office of the command surgeon, said that "the availability of adequate equipment for detecting hazards, frequent training exercises and availability of reports on actual operations are major factors in maintaining this capability."

To maintain its global deterrent capability, SAC keeps its alert aircraft and weapons in a constant combat ready configuration. As a result, a few incidents have occurred during the past several years involving nuclear weapons. The realistic training in disaster control made possible by these incidents demonstrated the effectiveness of the SAC program.

Among these incidents were the following:

- **March, 1958**—Part of a nuclear weapon fell from a B-47 near Florence, S. C., injuring six persons as the result of detonation of conventional explosives contained in the weapon.
- **July, 1959**—C-124 Globemaster, carrying unarmed nuclear weapons, crashed on takeoff one mile south of Barksdale AFB, La., but all seven crewmen survived. Disaster Control Teams evacuated the impact area (1,500-ft. radius) to protect personnel against possibility of detonation of high explosive charge. In response to public alarm and confusion over a non-existent radiation danger, state police evacuated areas adjacent to the crash site.
- **October, 1959**—B-52 carrying two nuclear weapons crashed 20 mi. south of Hardinsburg, Ky., after colliding in mid-air with a KC-135. Four crewmen survived after bailing from the B-52. Bomb casings of the retrieved weapons were unbroken, eliminating any danger from radiation.

Mere mention of radiation is sufficient to induce terror in most individuals, an unfortunate reaction that can evolve rapidly into a state of public hysteria when fanned by sensational news reports of incidents involving nuclear weapons. Since SAC aircraft and weapons must be kept combat ready at all times and since a portion of this force eventually will fly airborne alert

combat-loaded around the clock, it should be noted that the firing mechanisms for SAC's nuclear weapons are not connected except during actual firing tests or in time of war.

The Atomic Energy Commission in 1956 attempted to detonate atomic weapons three times by subjecting them to conventional explosions and once to a low-power nuclear detonation. The attempt failed in each test. Still the general lack of knowledge concerning radiation hazards constitutes a major problem for SAC.

Disaster Control Team at SAC Headquarters, led by Director of Materiel Maj. Gen. J. D. Ryan, is composed of between 10 and 12 specially qualified representatives of the following directorates: Operations, Materiel, Plans, Civil Engineering, Surgeon's Office and Information. Trained to cope with all aspects of a disaster situation, the team observes the performance of subordinate SAC disaster control teams, deploys to the scene of nuclear incidents involving SAC operations to aid base teams, and performs on-the-scene liaison between SAC Headquarters and other agencies involved, such as the Atomic Energy Commission, Public Health Service or responsible local officials.

A major feature of SAC's response capability to a disaster situation is the Command's operational communications system, which makes possible almost instantaneous reporting of nuclear incidents or disaster situations affecting the command. The combination of trained and ready teams, standby air transportation and excellent communications has demonstrated SAC's ability to provide prompt support and control of disaster situations.

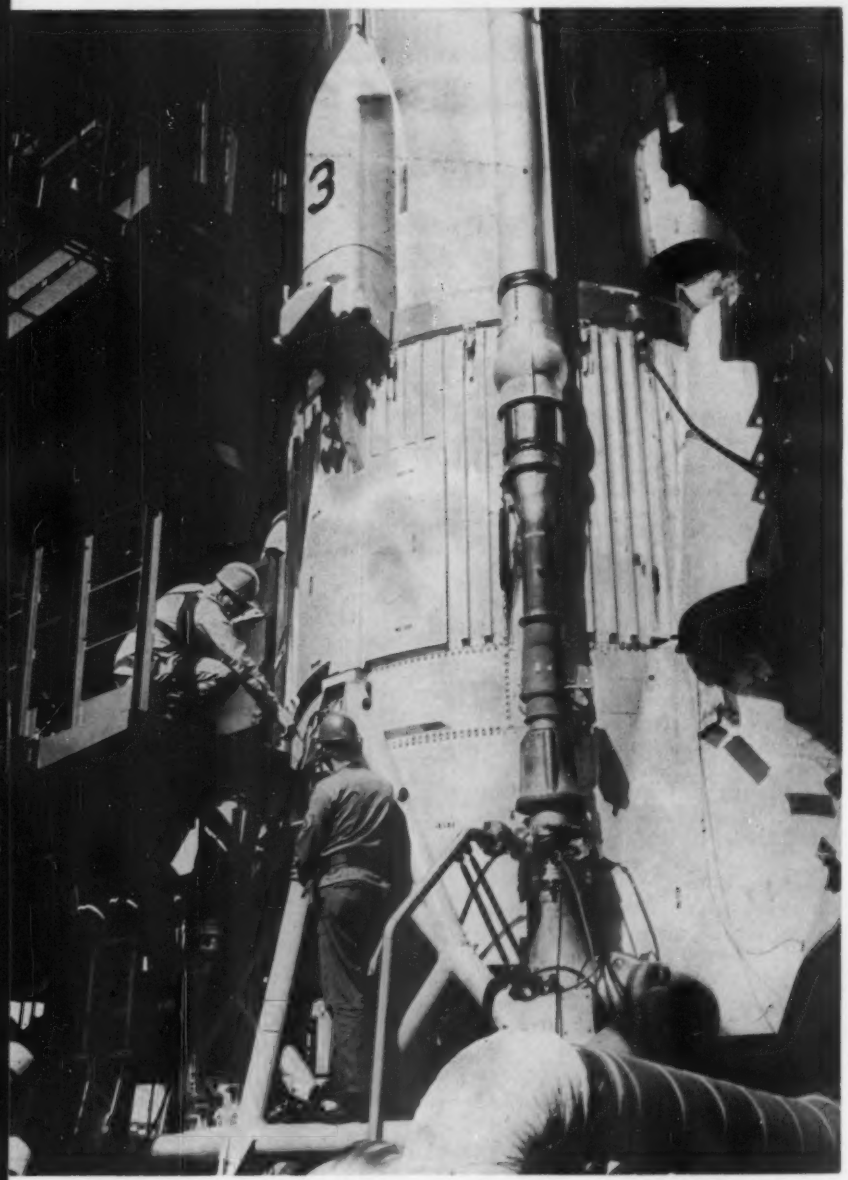
SAC has established special schools for disaster training, emphasizing refresher training in the use of disaster control equipment and interpretation of results. Teams are equipped with radiation detection and environmental sampling equipment, and with protective clothing, all of which is packaged for air transportation in the event deployment to an accident site is required. During the actual incidents involving nuclear weapons mentioned earlier, SAC teams collected environmental samples to prove that no radiation problem was present, and thus allayed public alarm over the nuclear age ogre—fallout.

In the event of a nuclear weapons accident which is beyond the capability of the agency responsible for coping with it, assistance is available from the Joint Nuclear Accident Coordination Center located at Albuquerque, N. M. Organized in March, 1958, by the AEC and DOD, it consists of staff personnel of the Defense Atomic Support Agency and the Albuquerque Liaison Office of the AEC. The Center has information on the location of all nuclear disaster response organizations in the DOD and the AEC, but has no response capability of its own. Its activities are restricted to the continental U.S. and its territories.

Department of the Navy operates the Naval Radiological Defense Laboratory as its official research organization for investigating all matters related to radiation protection, and maintains nuclear emergency teams similar to SAC's disaster control teams to provide support to naval organizations.

How effectively could SAC's Disaster Control Teams cope with an actual nuclear attack on SAC bases? There is no doubt that the Command would suffer severely from initial blast, thermal radiation and fire damage, and from radiological contamination of the areas. Most military hospitals, in the opinion of Brig. Gen. T. C. Bedwell, Command Surgeon, would be overwhelmed by a sudden influx of more than 50 serious casualties.

SAC's Disaster Control Teams, trained to respond effectively to all types of incidents involving nuclear weapons, are confident that they can fulfill their mission of minimizing casualties and damage resulting from an attack, and can swiftly restore operational capability to any SAC base following an attack.



MISSILE personnel receive special training in recognition and control of potential hazards associated with their work. Personnel are monitored for radiation exposure regularly.

MAJOR WEAPON in current SAC deterrent force is the Boeing B-52 nuclear bomber, with its advantages of positive control and recall capability, flexibility of use over enemy territory, use of higher yield nuclear weapons than are possible in missile warheads, smaller errors in bombing accuracy and re-strike capability. Missiles are now supplementing these B-52 qualities.

SAC Facing Broader Weapons Spectrum

The strategic aerospace force of tomorrow will embrace the widest technical spectrum of weapons yet seen in a military force, ranging from the ultimate development of supersonic bombers through second and third generation ICBMs to the initial employment of military space systems. The strategic aerospace force of tomorrow also will face added challenges in increasing efficiency of management of its varied resources, more effective exercise of command over a wider variety of weapon systems, and a more effective public understanding of its capabilities as an instrument of national policy.

SAC believes that no single weapon system can do the whole future deterrent job the way that the long range bomber served in the postwar period. SAC must rely in the future on a mixed arsenal of weapon systems designed for maximum survivability, flexibility of tactics and constantly increasing the cost and complexity of any potential enemy's surprise attack planning.

Continued development of the manned aircraft delivery system offers the advantages of positive control and recall capability, flexibility of use over enemy territory, use of higher yield nuclear weapons than are possible in missile warheads, smaller bombing accuracy errors and a re-strike capability.

Missiles will supplement these qualities in the future with their increased speed of penetration (even though launched later they will hit targets earlier), low vulnerability to enemy defenses, and penetration assistance to the following bomber fleet that can use the target areas blasted by the ICBMs as a penetration corridor.

The pattern of transition during the first half of the 1960s is clear:

• **Top priority on achieving** significant airborne alert capability for the heavy bomber force and increasing its penetration effectiveness by the addition of air-launched missiles.

• **Next priority for emplacing** and bringing to full operational readiness the liquid-fueled ICBM force and moving into the missile "era of plenty" with large numbers of solid fuel Minutemen to raise the ante of enemy resources required for any prospect of successful surprise attack to prohibitive technical and operational levels.

• **Developing military space** surveillance systems for operational uses as early warning devices and continuous photo and electronic reconnaissance capabilities, with swift and continuous data reduction processes.

By the mid-1960s, fundamental decisions will have to be made to determine the weapon system mixture for the period 1965-70, based on research and development efforts now under way.

Manned aircraft development will offer several new weapon systems that can increase flexibility and survivability of the SAC striking force. These include:

• **B-70 Mach 3 bomber** capable of armed reconnaissance and strikes with air-launched ballistic missiles. North American Aviation and General Electric Jet Engine Division are developing this system.

• **Nuclear-powered bomber** capable of continuous airborne operations for long periods as an early warning station, air-launched ballistic missile platform and ultimate penetration weapon. Convair, General Electric and Pratt & Whitney are working on this effort.

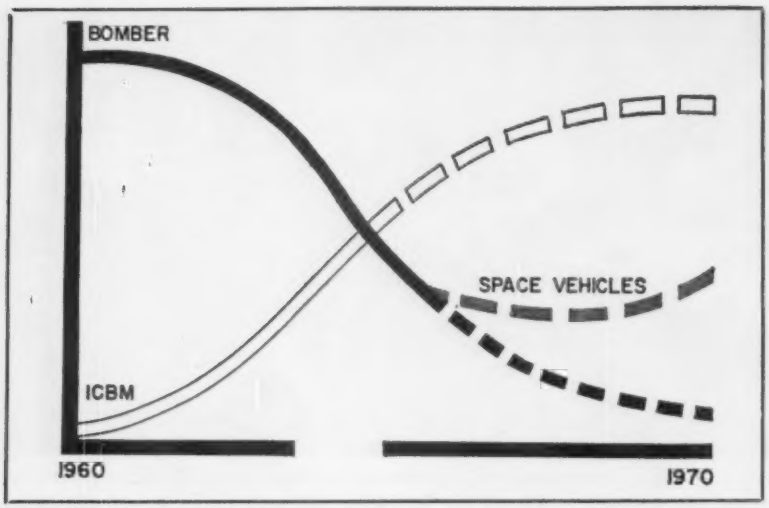
• **Dyna-Soar orbital** bomber that may be the first weapon system man will operate in space. Aerospace industry team headed by Boeing Airplane Co. and Martin Co. are developing this vehicle.

Missile technology is still in its infancy. SAC's first generation ICBM can be compared with the Model T Ford in the development of automotive technology. Considerable improvements in reliability, guidance accuracy, larger warhead yields in lighter packages, and flexibility in tactics can be expected from follow-on generations of missiles. Low level, hypersonic missiles following non-ballistic trajectories and extremely long range missiles that could be fired the long way around the world instead of over the shortest ballistic trajectory are among the possibilities being actively explored.

Significance of Space

Air-launched ballistic missiles such as the Douglas Skybolt and the submarine-based Polaris missile offer increased enemy target complexity when combined with the mobile Minuteman.

"We may think in terms of space," said Gen. Power, "although space is merely a medium and not a weapon. But as air supremacy meant control of the battleground beneath in World War II, control of space may well mean control of the globe in a future war. Hence the conquest of space is more



FORCE APPLICATION chart shows present primacy of manned bomber in SAC's strategic deterrent force, with missiles being introduced in a complementary capacity. As ICBMs grow in numbers, reliability, range, yield and accuracy, they will assume a more significant role to a point where they will support a major share of the load until introduction of manned space systems again reverse the trend. Crossover point implies equal capability rather than equal numbers of manned aircraft and missiles.

than a race for scientific firsts and national prestige.

"Whether we like it or not, it is still primarily a question of survival.

"No one can foretell what problems will arise in extending our defenses hundreds of thousands of miles above the ground which we are dedicated to protect. But it is not beyond the realm of possibility that this may require manned spacecraft which would orbit the earth in a continuous space alert.

"Their purpose would be three-fold—to provide instant warning of any act of aggression, to intercept hostile missiles and spacecraft, and above all to deter aggressions as heretofore.

"The day when this might become a reality may still be far in the future. Nevertheless, we must anticipate it in our long range planning for the benefit of the men who will have assumed our duties by then and must be equipped to carry out these duties. Toward this end SAC is preparing itself for the time when it must begin to lay the foundation for whatever challenge the space alert may entail for SAC's men of tomorrow."

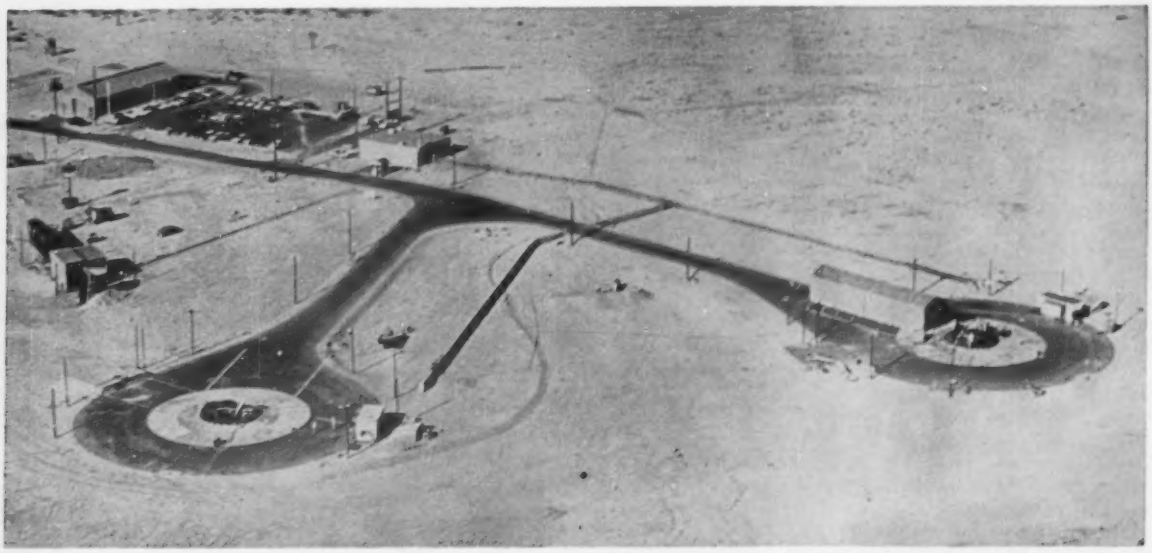
Management of its material and human resources poses another major challenge for SAC tomorrow. Initial use of electronic computers and data reduction systems for operational planning, intelligence and exercise of command functions has just begun to reveal the possibilities for increasing efficient organization, operation and control of SAC's future mixed forces, and to enable it to expand its deterrent capability within the portion of national resources that can be devoted to this purpose.

Management Challenge

Major management challenge lies in the field of personnel where SAC faces the job of training and retaining a career group of highly skilled specialists in contrast to the relatively higher costs and appreciably lower operational efficiency of a large flow of temporary short-term personnel.

Whatever future success SAC enjoys in exerting an effective deterrent to war and in supporting U. S. policy on the international scene will have to be based on a foundation of increased public understanding of its position, problems and policies both in this country and abroad. Unless the American people develop a better understanding of SAC in its transition period they will be unable to support its activities with sufficient resources and intelligence to increase its effectiveness.

It is also increasingly essential that allies, neutrals and any potential enemy gain an equally sound appreciation of SAC's future shape and strength in order for its deterrent capability to be fully effective.



TEST SILOS with a shed covering prototype missile are seen in aerial view of Minuteman intercontinental ballistic missile silo test complex at Edwards AFB, Calif. In background are the control center and various service buildings for the complex.

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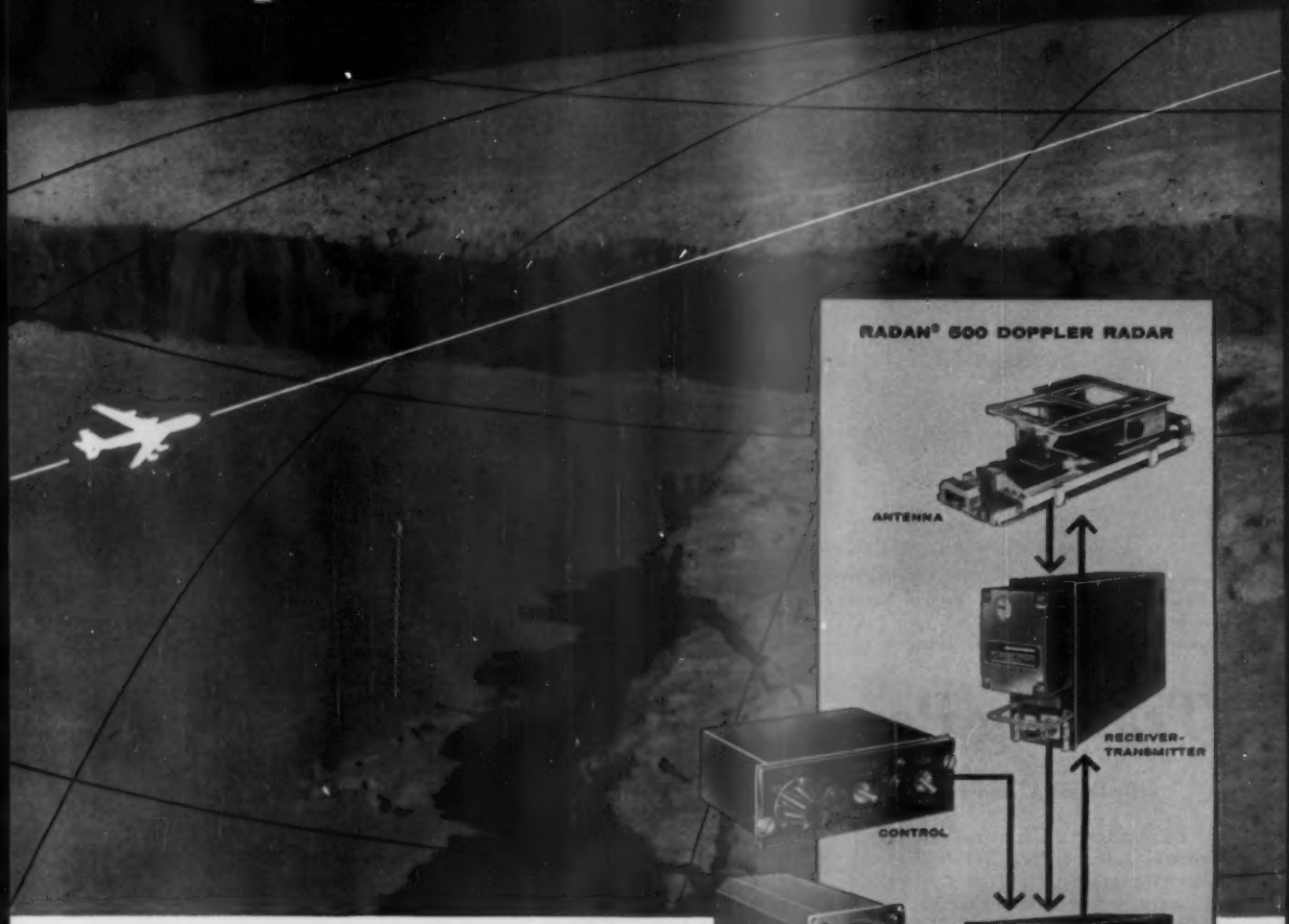

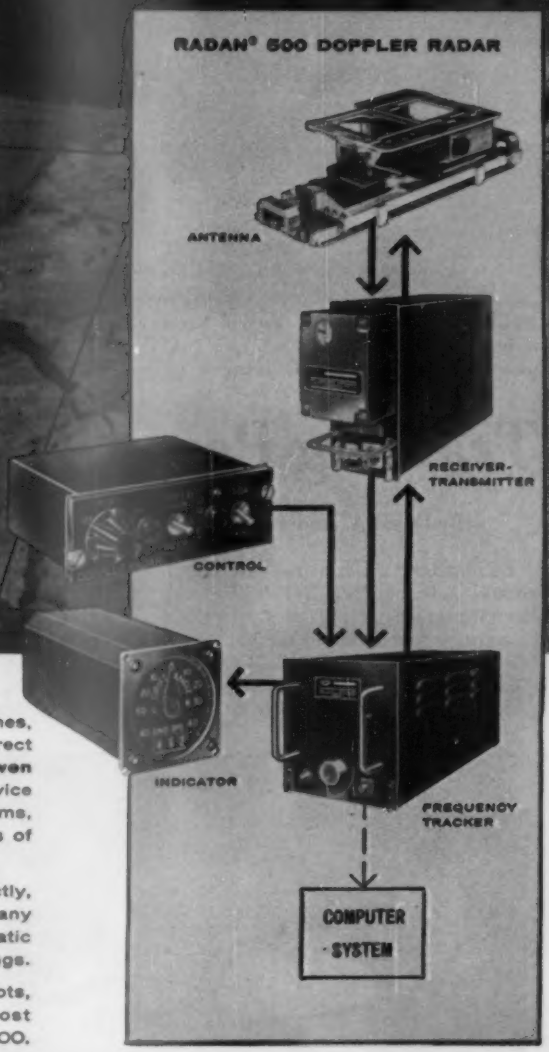

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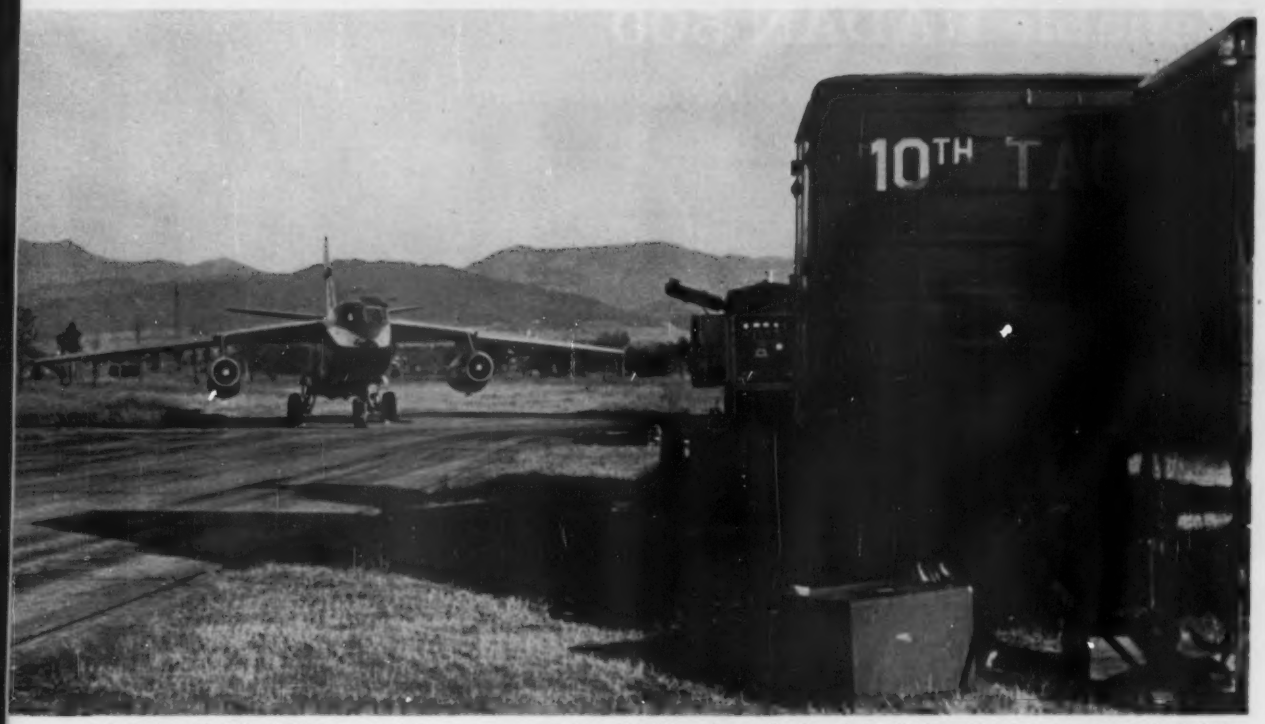

DOUGLAS RB-66B of 10th Tactical Reconnaissance Wing, USAF, waits on hardstand for final preflight servicing and check before night mission during Royal Flush Five, NATO aerial reconnaissance exercise. Trailers at right of picture are mobile field laboratories for processing film, printing and enlarging pictures and photo interpretations.

Training Pays Off in RB-66 Wing's Score

By David A. Anderton

Bremgarten, Germany – Air and ground crews of USAF'S 10th Tactical Reconnaissance Wing worked their Douglas RB-66B Destroyers at peak efficiency to beat a Royal Air Force Canberra Pr. 7 unit by the highest point margin scored in Royal Flush Five, NATO's big annual aerial reconnaissance exercise.

The 10th competed only in night missions, a category new this year to the Royal Flush events. Final s ore for these missions showed the USAF outfit leading by 2,988 points to the RAF's 2,258. Margin of 730 points represented the major contribution to Fourth Allied Tactical Air Force's 871-point lead over Second ATAF when final scores for the whole event were tabulated (AW May 30, p. 36).

Competition in the night event was tough; Royal Air Force units have traditionally been strong both in night operations and areial reconnaissance, and the competing Canberra teams were the best available. So were the 10th Wing teams, which had been chosen in a long proficiency run-off among the operating squadrons of the wing.

WORKING AGAINST umpire's stop watch, crew of RB-66B works out navigational problem for a night photo-reconnaissance mission during Royal Flush Five.

RAF Challenged

Some time before the event, Capt. Silas G. Upchurch, staff photo officer, stuck his neck out and said: "We expect to win, and to look good doing it." This kind of claim is an immediate challenge in any competition, and the fact that the 10th wing is stationed in England in the middle of Royal Air Force territory made the implication of Upchurch's statement much more serious.

But the rest of the Wing was out to win also, and well before the end of the competition, they were circulating a superb radar-scope photograph of one of their objectives which had been weathered in, clearly and bluntly labeled. "10th TAC Recon Wing; Royal Flush

AERONAUTICAL ENGINEERING

ELECTRONIC COUNTERMEASURES package distorts the fuselage tail of this Douglas RB-66B on standby for a night photo-reconnaissance mission. Original version of the plane had a twin 20-mm. cannon turret as rear-facing armament, but this unit has been replaced by the ECM package. RB-66B aircraft carry no armament either internally or externally.

GROUND CREW waits in shadows near hardstand at Base Aerienne 136, operated by the French Air Force near Bremgarten, Germany. RB-66B in background is ready to go on night photo mission during NATO's Royal Flush Five exercise.

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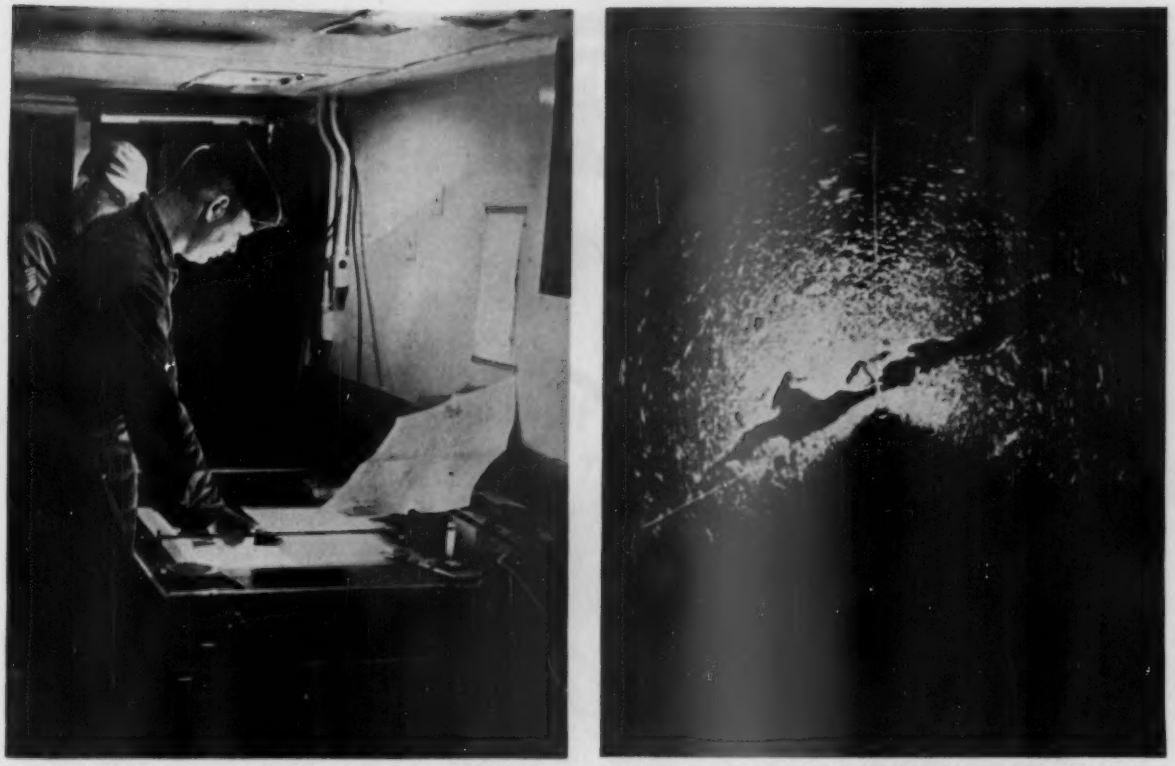


WET NEGATIVES get first reading (left) for a "hot report" immediately after development of exposed film is completed. Photo-interpreters make their first intelligence estimate working directly from wet negatives on this reading table in one of the mobile trailer laboratories of the 10th TAC Recon Wing. Radar scope photograph was unconventional way of proving to judges that RB-66B was over weathered-in target on Royal Flush Five mission. Crew had bad weather in target area, prohibiting low-level night photography, made this run-in and photographed the radar scope to prove they had been on the target. Target assigned for the mission was the bridge which shows in this picture (right) directly under the reference line on the scope.

Nite Photo Champions." The 41-man team under Maj. Thomas E. Anton had been practicing for weeks for the event. Beginning in March this year, night practice missions under the expected rules of Royal Flush were flown in a series of tough crew competitions. Field laboratories were set up, airplanes parked on hardstands the proper distances away from facilities and briefing rooms, and the entire routine of the practice period was conducted in a way to simulate the environment of the base at Bremgarten.

Time Bogies

Time bogies were set for processing and interpreting films and prints, and laboratory technicans and interpreters worked to cut these down. They succeeded in getting all the bogies down to about half their estimated value.

These practice sessions resulted in the selection of three top crews and a supporting force of 30 airmen. Besides Maj. Anton who acted as team captain, and Capt. Upchurch, there were three three-man aircrews.

Capt. Boyce D. Beverly, pilot, and Capts. William K. Cole and Robert C. Yirka, navigators, emerged as the top-scoring crew in the night events. The other two crews included Capt. Titus C. Thomas and 1/Lt. Kenneth D. Waits, pilots; Capt. Lawrence C. Russ, and 1/Lts. Donald A. Rigg, Tunney J. Oydna and Edwin L. Stanford, navigators.

Of the 30 men participating, 20 were in airplane ground crews. Eight worked the photo lab and two were photo-interpreters.

The team left on May 10 from its headquarters at RAF Alconbury, where the practice sessions had been held, and ran through a series of practice missions again from Base Aerienne 136 operated by the French Air Force here. Then, satisfied that all they had left to do was to win the competition, they waited for the opening gun.

Mission Rules

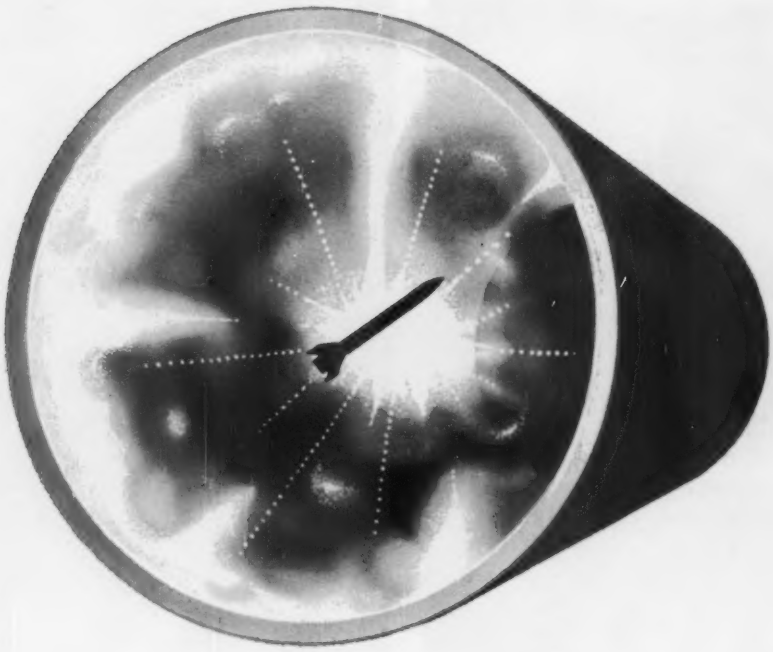
Eight targets were chosen by the operations staff of Royal Flush Five for night missions. Original plan was to fly only two of the three nights during the competition, with a third night available in case weather made operations impossible on one of the scheduled nights.

Standard sortie was against two targets on a total track distance of 900 naut. mi. Two sorties were flown each night by the two competing teams, with each having a third aircraft and crew in reserve in case of an aborted airplane or engine trouble.

There were restrictions on the flight plan tending to make the competition more like an operational mission than a training exercise. No land-based navigational aids could be used, and "low and slow" passes at the target were ruled out. Pilots had to hold minimums of 2,000 ft. altitude en route and 500 ft. over the target. Minimum speed permitted during the target runs was 300 kt.

Point scoring was complex, a necessity because of the differences in the types of aircraft participating and in order to be as objective and exacting as possible. Points were awarded in two basic categories: timing and proficiency. Scores in each group were separate, and penalties in one did not detract from the other.

Timing for the mission began when judges handed the crews sealed envelopes containing the detailed mission briefing. From that instant, the three-man crews had a maximum of 40 min. to plan their flights, and get their airplanes ready to roll. The flight itself was timed from takeoff to return, marked



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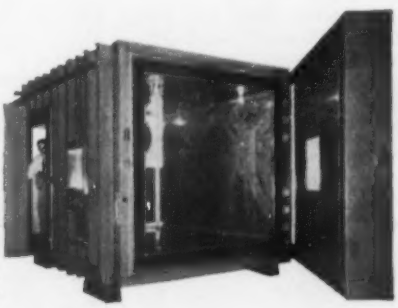

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either by a low pass or a radar check. Pattern, landing, and taxiing times did not count, but the timed portion of the mission began again when the engine was cut.

Final time was called when the last intelligence report was handed to the judges.

Point Scoring

Entire purpose of each mission was to produce two sets of intelligence reports on each target. First reports—called "hot reports" in reconnaissance jargon—were electrically transmitted to the judges, and were prepared from wet negatives read and interpreted by photo intelligence personnel. These reports covered the directly observable characteristics of the target, and contained information necessary to decide whether or not to strike it immediately, and to estimate the opposition in the event of a strike.

Second reports are "immediate reports," prepared from prints or enlargements of the pictures taken of the target.

These are detailed reports, which attempt to assess the importance of the target as an over-all part of the enemy's strength and to wring out the last drop of intelligence information to help determine battle strategy.

Preparation of these reports was scored under the proficiency portion of the mission, up to a maximum of 360 points.

Maximum score for either "hot report" or "immediate report" was 90 per target or 180 per sortie. Points were not awarded for quality of the photo processing, because of the many intangible factors involved. But it was obvious to everybody working in the labs that the better the print, the easier the job of photo interpretation.

Timing Phase

Scoring for the timing phase of the missions was different. Maximum point score possible in any given mission was 410 points, and points could be both gained and lost. Every minute of flight planning time over the bogie of 40 min. cost the team 10 points, but there was no bonus for completing planning ahead of time.

If the estimated flight plan time was exceeded, it also cost 10 points per minute. If mechanical or crew errors forced a landing anywhere away from home base, all timing points were lost, but if the reports could be delivered to the judges, proficiency points could be awarded.

First phase of scoring allowed a maximum of 200 points between the time the engine was cut and the time the first "hot report" was sent to the judges. Every minute of time cost 10 points. Second phase allotted 210 points to the

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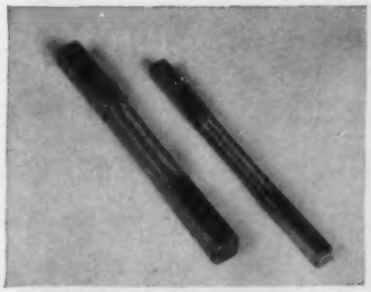
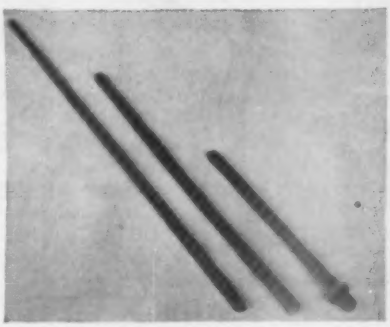
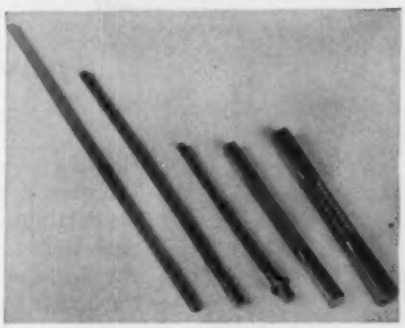


Above: These Flexible-Core Couplings with squared end sleeves are manufactured entirely of stainless steel; engineered to operate at temperatures as high as 1000° F.



At Left: In these ¾" flexible core assemblies, the core is swaged to provide the square ends forming the engagement for the drive. Allowance in the end squares compensates for length variance in the drive.

At Right: Especially designed to meet specific requirements, couplings engineered with cores of flexible shafting may be of varied length, diameter and basic design. As illustrated here, some assemblies employ squared end sleeves or fittings . . . while others have the core itself squared at the ends.



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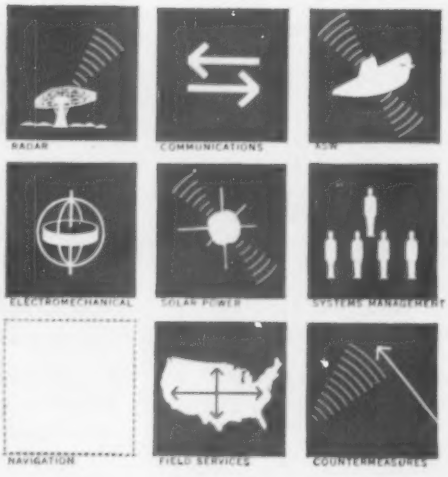

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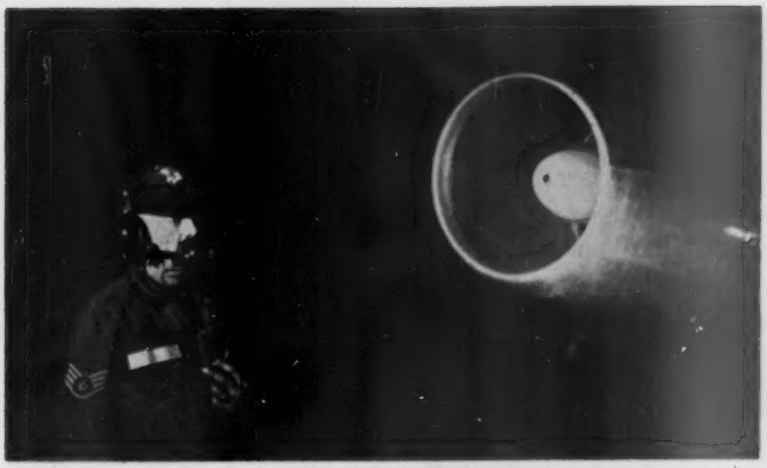

GROUND CREW runs up Allison J71 turbojets of Douglas RB-66B before takeoff.

time period between handing in the "hot report" and the "immediate report." Each minute during that process cost three points.

Thus the maximum—and unattainable—score for the night events was 770 points per sortie, or 3,080 total for four missions. Tenth Wing's 2,988 point score for the missions is considered phenomenal.

Wing Equipment

The 10th Tactical Reconnaissance Wing converted to Douglas RB-66B aircraft beginning in December, 1956, about two and one-half years after the first flight of the prototype airplane. The RB-66B is roughly a 70,000-lb. gross weight airplane, with a wingspan of 72.5 ft. Powerplants are twin Allison J71-A-9 turbojets rated at a nominal 10,000-lb. sea-level static thrust.

The airplane is ruggedly built, and can be thrown around on the deck at high speed. It carries neither offensive nor defensive weapons. The original production RB-66Bs had a twin 20-mm. tail turret, but operational models have had the turret replaced with a huge, fuselage-distorting package containing electronic countermeasures equipment.

Cameras for either night or day missions can be mounted; two night cameras were installed for the Royal Flush exercises.

Ground Lighting

Ground lighting during missions is done one of two ways; either with flash bombs, which are used on high-altitude missions, or with flash cartridges, used during low-level sweeps and standard for Royal Flush Five. These cartridges are installed in the bomb bay of the RB-66B, and are ejected in ripple-fire. Cartridges have either a one- or two-second delay and burst below the airplane after an ejected drop from the bomb bay.

Aboard the airplane, a fast-acting exposure control system senses the first emission of light from the cartridge flash, and opens the shutter of the camera when the flash is delivering its maximum light a split-second later.

Samples of night photographs taken during the practice missions showed remarkable clarity of ground objects. Although the lack of shadows makes photo-interpretation more difficult, the detail shown on single pictures was excellent.

Wing Makeup

USAF's 10th Tactical Reconnaissance Wing, commanded by Col. James D. Kemp, is part of the United States' contribution to NATO, and a major component of Fourth Allied Tactical Air Force. The Wing has its headquarters at Royal Air Force Station Alconbury in East Anglia, south of The Wash.

There are four squadrons in the wing: 1st and 30th TAC Recon Sqdns., based at RAF Alconbury and 19th TAC Recon Sqdn., based at RAF Bruntingthorpe, have primary responsibility for visual and day-or-night photo-reconnaissance.

The 42nd TAC Recon Sqdn. at RAF Chelveston handles weather and electronic reconnaissance.

The move to England was recent, and followed the general reshuffle of USAF units in Europe when French President Charles de Gaulle refused to permit storage of nuclear weapons on French territory. The 10th Wing had been based at Spangdahlem Air Base in Germany, but had to make room for shorter-ranged fighter-bomber outfits moving in from bases in France.

Before its tour in Germany, the Wing was based at Toul-Rosiere Air Base in France, where it was re-activated in 1952 with a major portion of the former 117th TAC Recon Wing forming

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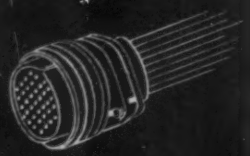

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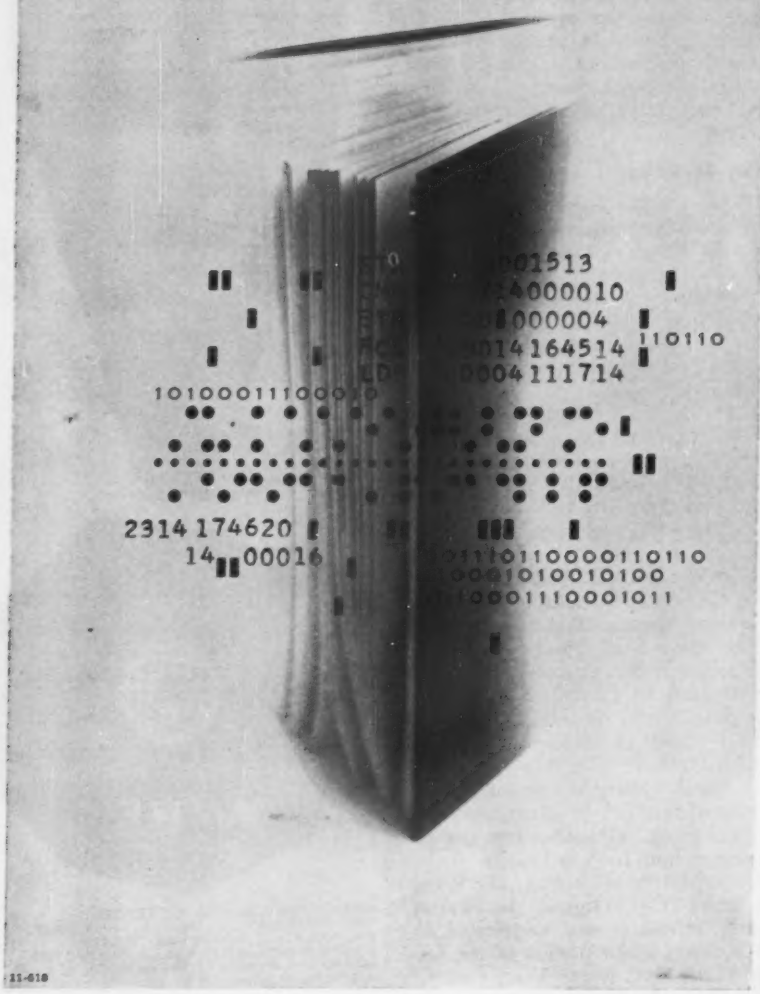

11-610

the core of the unit. Before that, the unit had a five-year history of paper status and inactivation.

The Wing has a long association with England. During World War II it was based there for its major contribution to the war: low-level photography of German coastal defenses immediately prior to D-Day. Pilots of the 10th flew sweeps "one prop radius off the sand" in 232 sorties during a two-week period, bringing back detailed photos of beach layouts and defenses. Last sortie was made just a few hours before the landings, and earned the unit slogan "First on D-Day" plus a Distinguished Unit Citation.

8,000 Missions

Between its arrival in Europe in February, 1944, and V-E Day, the 10th flew more than 8,000 missions in more than 13,900 individual sorties. The Wing shot down the last enemy aircraft and flew the last mission in the European theater, and added to its slogan so that it then read, "First on D-Day and Last on V-E Day."

Since the reactivation of the unit as part of USAFE's operations the 10th Wing has racked up a series of wins in photo-reconnaissance competition conducted within the USAF units on this side of the Atlantic.

Design mission of the RB-66B was night photographic reconnaissance, but the plane's capability includes both high- and low-level night work and day mapping mission.

Camera installations are varied depending on the mission.

Pinpoint Navigation

Pinpoint navigation is one major requirement of any reconnaissance system, and the RB-66B is full of avionic gear including probably the first doppler navigation system—AN/APN-82—to be installed in a production aircraft. System gives the navigator automatic indication of his present position, groundspeed and drift angle plus precise heading reference for other avionic systems.

Other navigation aids installed include an APN-22 radar altimeter and a B-6 driftmeter which are specialized for the reconnaissance job, and an N-1 compass system plus receivers for glide path, omnirange, marker beacon and radio compass, all standard equipment for the B/RB-66 series.

Plane also carries APS-27 search radar and AMT1 radar with a 45-in. scanner.

In addition to a varied camera installation depending on mission, the plane also has a radar recording camera and a universal camera control system (UCCS) which is primarily a computer controlling camera pulse rates, film transport rate and drop intervals for night illumination.

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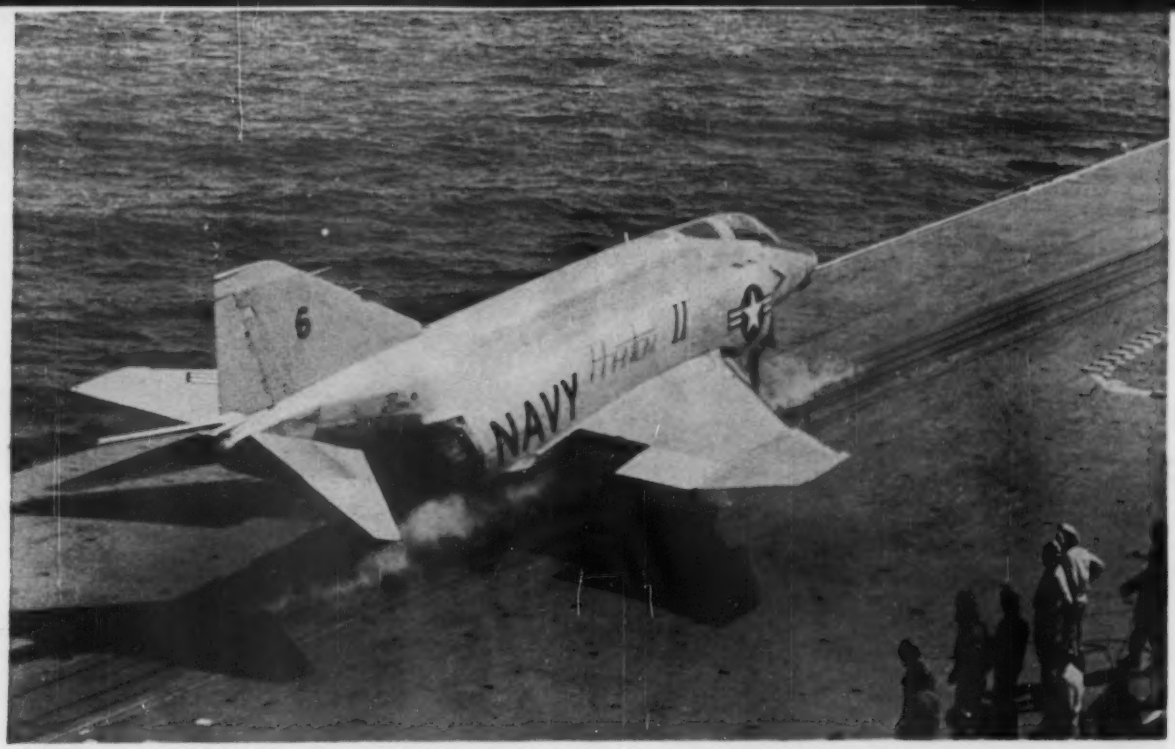

MCDONNELL F4H Phantom II is catapulted from the carrier Intrepid in the second series of carrier trials.

Supersonic F4H-1 Tested on Carriers

TAIL HOOK still down, the F4H takes off again after missing engagement wire on Intrepid's angle deck. The airplane carried a 600 gal. belly tank and two of its four Sparrow III missile stores in the second trials.

Washington – McDonnell F4H-1 Phantom II, the only Mach 2-plus fighter now scheduled to be purchased by the Navy, is expected to enter fleet service in October.

The Mach 2.4-plus Phantom II will be the only Navy aircraft in its class after the early 1960's, when current supersonic fighters are phased out of service and fleet equipment begins to reflect the Navy's new air defense concept of using relatively slow aircraft to launch long range, high performance missiles.

Next Navy contract for the development of a fighter is scheduled to be for the Missileer, a Mach 0.9 aircraft, which will fire the Eagle air-to-air missile with a range originally specified to be 75 mi.

Present armament planned for the F4H-1 are four Raytheon Sparrow III missiles and four Philco Sidewinder infrared guided missiles, so the aircraft must be less than five miles from its target when missiles are launched.

Comparative Effectiveness

Comparative effectiveness of the slow interceptor and its long range missile and the fast interceptor with a short range missile is still under debate both inside and outside of the Navy. It apparently has not been possible to settle this argument conclusively on paper and final proof must wait for flight tests of both systems.

Flight tests with the Phantom II have shown that it will operate effectively up to the temperature limits of

F4H APPROACHES ramp of the Independence in first trial series. Parked are F8U, F11F, A3D and A4D (left to right).

WINGTIP folding of the F4H is demonstrated on the Independence (above). A minor hook skip problem developed in first trials but is not considered critical. Airplane lands on Intrepid (below) with belly tank. Sparrow IIIs were carried in first test series but not the tank.

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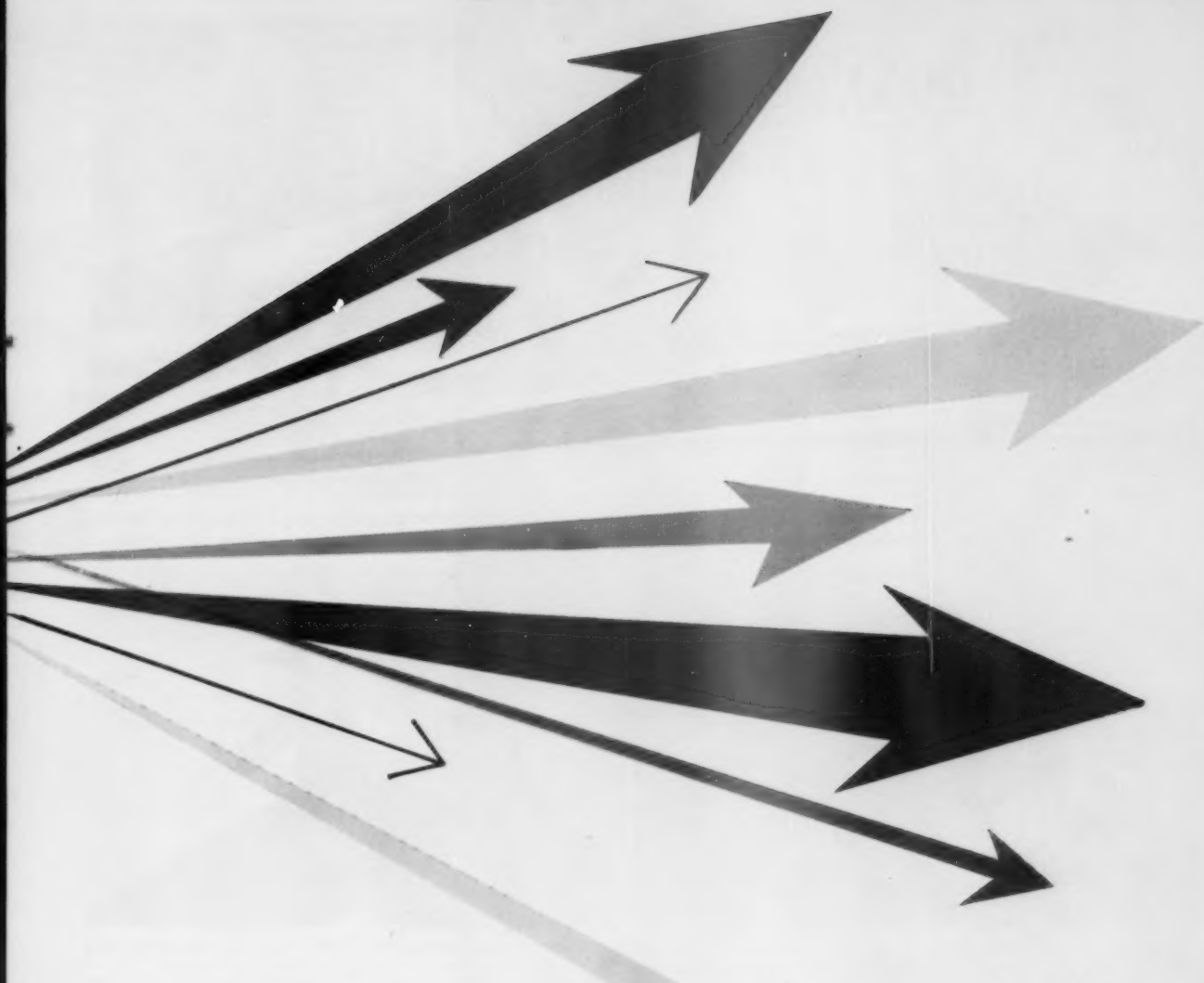

As the world's weapons systems increase in sophistication, no one weapon in America's arsenal of defense can "do it all." Among our strategic attack forces, there is a strongly growing philosophy that a proper mix of penetration aids is our only adequate answer. Temco is firmly dedicated to this philosophy. ■ Engineers and scientists in Temco's Missiles & Aircraft Division have made their own studies in depth on the probabilities of a penetration aids mix. They have mathematically proved its high increase in effective kill. Their answer to the argument about the multiplicity of support problems attendant to this mix is this: the pay off is so fantastically big, it is the only answer. ■ As a leader in the development and production of penetration aids, Temco has long been an active supplier to the Department of Defense. Two of its major products are the Corvus penetration missile and a video correlator — products vital to the mix.

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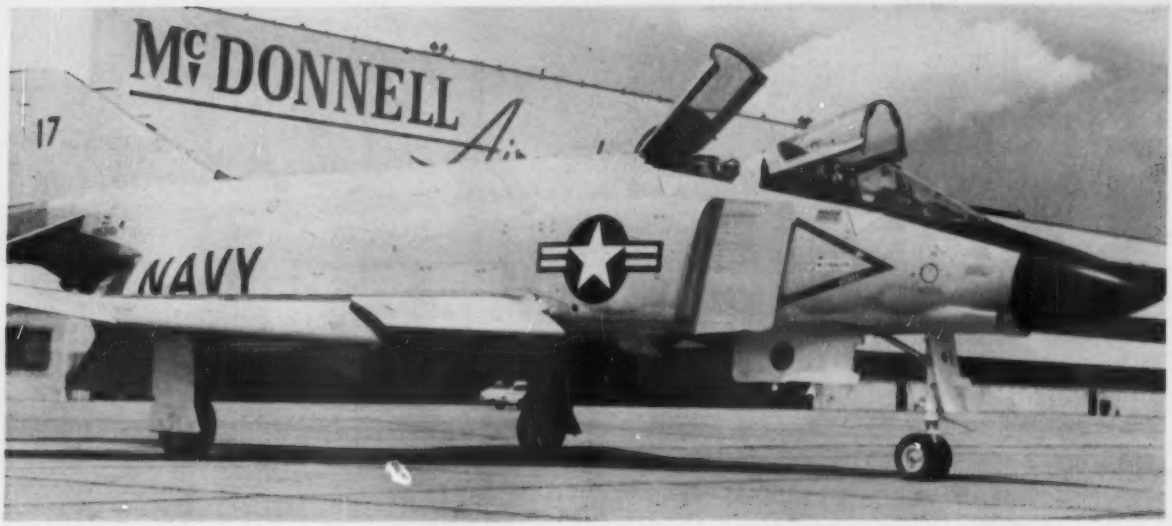
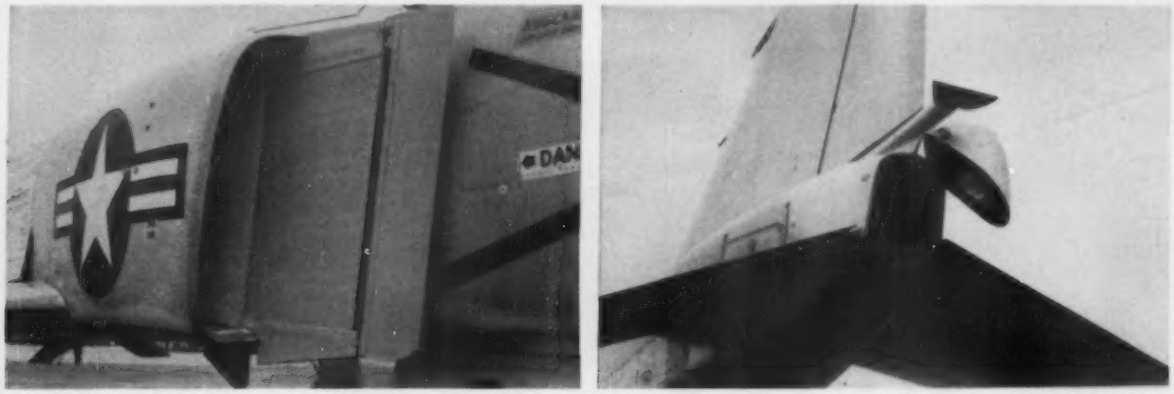
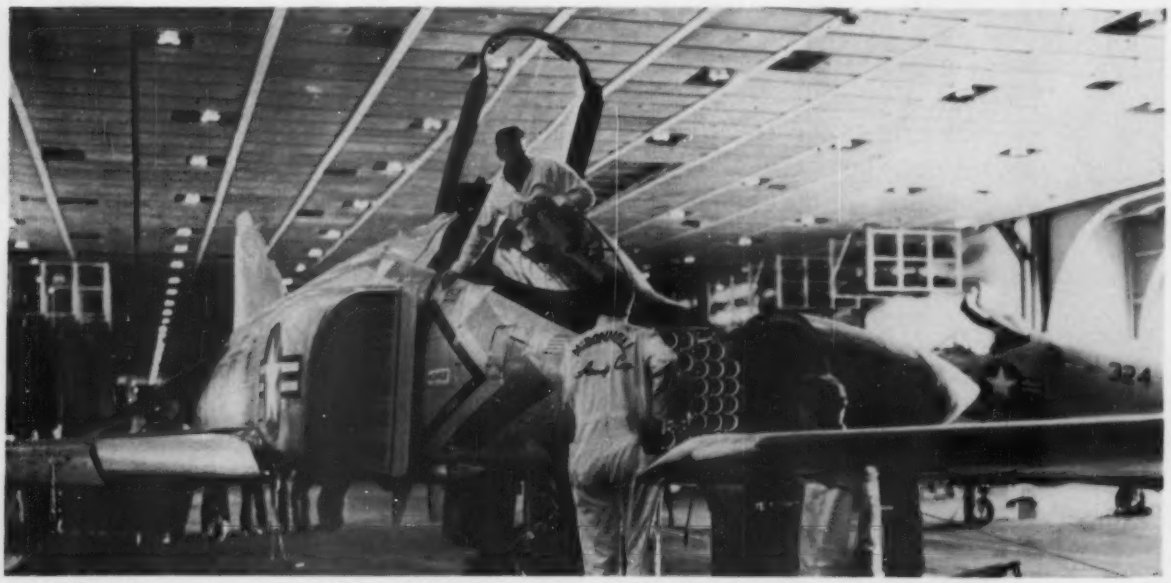


TWO-MAN flight test crew takes a McDonnell F4H out of the hangar area with the high lift devices on the wing leading and trailing edge deflected. The aircraft has a blowing type boundary layer control system to augment both the leading and trailing edge flaps.



ENGINE AIR INLET on F4H has one fixed and one movable ramp and a variable area throat section (left). Tail compartment for drag chute is open at right. Vent above the door pressurizes fuel tanks.



MAINTENANCE crews inspect the F4H—the No. 6 airplane—on the Independence hangar deck. Test instruments in nose are photographed by camera, also mounted in panel, by means of a mirror in radome section.

its aluminum outer structure and that the only way to improve its performance under the present state of the art would be to build a steel aircraft with a higher limiting structural Mach number.

Detail specifications of the F4H were finalized in July, 1955, during a period when the most serious question surrounding supersonic aircraft was their stability and control, and these considerations were watched more closely than any other in the F4H design.

Navy was concerned over the stability problem in 1955 because many of the supersonic aircraft now operational had flown initially by that year and many serious troubles had been exposed. As these troubles were solved, flight time was built up and general understanding of the problems increased. The Navy pressed for an aircraft that would be substantially better in stability and control performance than the first generation of supersonic aircraft.

This apparently has been accomplished with the Phantom II, because the aircraft has been flown for several hundred hours over its entire flight envelope without any type of artificial stability device. The aircraft is statically stable in all flight regimes and angles of attack. Dynamically there have proven to be only a few attitudes and speeds at which it is possible for the pilot to induce oscillations which are unpleasant or difficult to control.

To date, however, only company pilots and pilots from Navy test groups have flown the aircraft and their precision flying ability is generally better than the average service pilot's. Production aircraft will be equipped with automatic damping equipment on all three axes to guard against pilot induced oscillations.

Flight Limitations

In contrast, the safe flight envelopes of most of the first generation supersonic aircraft are limited if their oscillation damping systems, static stability correction devices and/or stick bumpers become inoperable. These flight limitations usually hold for the most experienced test pilot as well as service pilot.

Most of the operational Phantom II aircraft, now covered by production contracts totaling $310 million, will be equipped with General Electric J79-GE-8 engines, which provide greater thrust and generally better performance than the J79-GE-2 engines installed in the 23 developmental aircraft and the first few production models. Main engine air inlet system on the airframe will have to be modified slightly to get the full power out of the −8 engine.

Basic design of the engine air duct system will be unchanged, however. It has a fixed ramp near the fuselage, projecting ahead of the duct inlet,

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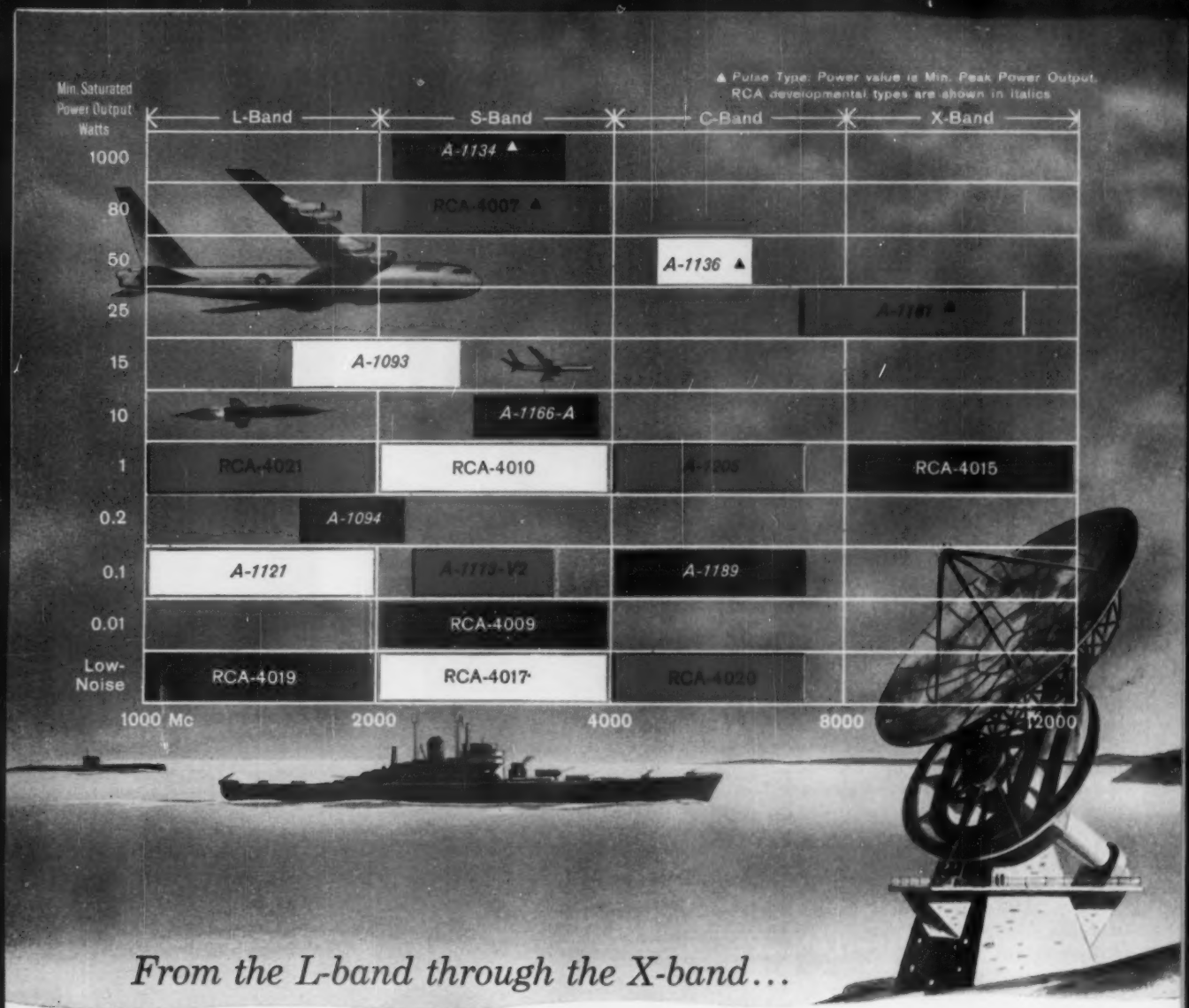

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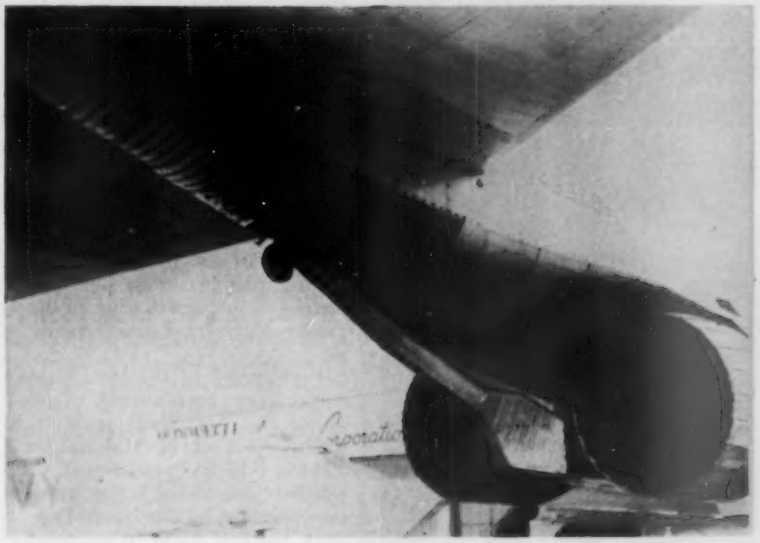

STAINLESS steel shingles are used as outer skin in the hot sections of the F4H tail. Layer of insulation material is under the shingles to further protect the main load bearing structure. Life of this type of heat shielding structure has been increased greatly in the past few years through improved design knowledge.

which is cut back slightly at the bottom but is otherwise almost square with the remote airflow. Behind the first fixed ramp is a movable ramp and behind that is a movable wall at the duct throat. Boundary lawyer air is bled off in three ways—first, in a large bleed between the first ramp and the fuselage; second, through the perforated skin on the movable ramp; and third, into a slot provided on the duct wall just behind the second ramp.

Position of the shock wave created by the first ramp depends primarily on the Mach number at which the aircraft is operating. High-drag spillage of air around the duct lip when the shock wave is positioned out ahead of it is prevented by adjusting the second ramp and duct throat area so that the duct does not admit more air than the engine needs.

Cooling air for the engines is supplied by the main air inlets and is then

Navy A3J Takes Off for Mach 2.02 Flight

North American A3J Vigilante takes off for a flight during which the Navy attack aircraft attained Mach 2.02 at 47,000 ft. altitude. Wing leading edges are drooped and flaps, which have boundary layer control, are down. Tricycle landing gear is retracting. Jacqueline Cochran, president of the Federation Aeronautique Internationale, was in bombardier-navigator's compartment aft of the pilot on this flight, made over southern Ohio.

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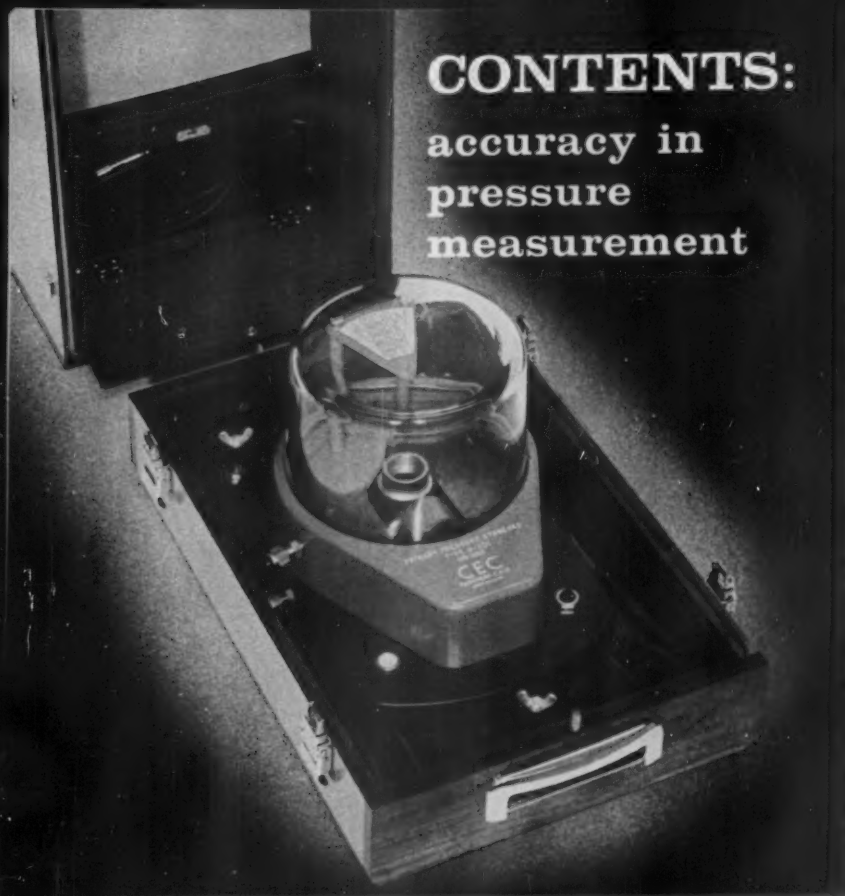

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ducted down the full length of the engines and the afterburners and dumped at the aft end of the fuselage. An auxiliary door has been located in each of these cooling ducts to provide extra air during static and low speed operations. If the doors had not been provided, the pressure at the engine inlets would be lower during low speed flight and static operation than the pressure at the exit of the cooling ducts. Cooling air then would be drawn into the aircraft from the rear, passing over the hot sections of the engine first and heating up the compressor section and main engine inlet air.

Performance of the aircraft and the engine have been almost trouble-free during the two carrier trials to date. First of these was made aboard the 78,700-ton USS Independence (CVA-62), which is one of the largest attack carriers operated by the Navy. They were made last Feb. 15 to 20 and totaled 18 launches. The second trials were made aboard the USS Intrepid (CVA-11), a much smaller carrier displacing 41,900 tons when fully provisioned. These trials, held last Apr. 25 through 27, consisted of more than 20 catapults and arrested landings.

Only trouble that developed during the trials was skipping of the arresting hook when it hit the deck. This problem has been adjusted by the Navy many times in the past through cut and try changes in the hook and it is not considered to be a serious defect.

During the trials, wave-offs were flown on one engine without using the afterburner. The engines proved that they can be accelerated from the approach power setting to full thrust within one second.

Length Limits

The successful performance of the Phantom II on both of these carrier trials proved the desirability of one of the Navy's main requirements for the aircraft. This was a maximum length of less than 59 ft. so that it could be handled rapidly on the smallest of the Navy's 14 attack carriers. The Intrepid is one of these.

Carrier approach speed on the F4H is about 125 kt. This is achieved through the aid of blowing-type boundary layer control over the short span flap on the trailing edge of the wing and blowing behind the leading edge flaps which fold down in three sections. The inboard section of the leading edge flaps deflects 30 deg., and the two outer sections and the trailing edge flap all deflect 60 deg.

Major portion of the additional lift generated in the landing configuration is provided by the blown flaps. This allows the angle of attack during landing approach to stay about 10 deg. so that pilot visibility is good and the nose

←Circle Number 164 on Reader-Service Card

gear can be approximately the same length as the main gear.

Some Navy fighters of previous years, such as the F3H and the F7U did not have the benefit of boundary layer control systems on their flaps and their approach speeds were kept down by using leading edge slats. These high lift devices extended forward of the leading edge, increasing the wing area in the same manner as the Fowler flap. While slats increase the maximum lift coefficient, they also increase the angle of attack in the approach and landing configuration when maximum lift is produced. This necessitates a drooping nose to improve pilot visibility and very long nose gear to prevent undue angular acceleration loads on the nose during arrested landings and to allow the aircraft to develop maximum lift during catapult takeoffs.

Design Aim

McDonnell is convinced of the attractiveness of twin-engine fighters, and the general layout of the F4H evolved primarily as a result of the company's desire to achieve one simplification and improvement in this type of aircraft over the F-101 it developed for the Air Force. This improvement was to use a low wing so that the landing gear could be kept short, light and wide-tracked for carrier landings. It also allowed the wing structure to be continuous and eliminated the heavy forgings which carry the wing loads around the engines on a mid-wing aircraft like the F-101.

The low-wing location combined with the high position of the aft fuselage to allow for the engine exhausts meant that the horizontal tail would have to have cathedral in it to lower its center of area to the proper position behind the wing. At high speeds and high angles of attack, the horizontal tail must be low if it is to stay out of the wing tip vortices and remain effective. Tail cathedral angle was somewhat restricted to keep it from getting into the engine exhausts.

Another unusual feature of the Phantom II is the dihedral angle of more than 12 deg. on the wing tips. This sharp dihedral on the tip was necessary to give the wing the effective 3 deg. dihedral it needed at supersonic speeds to make coordinated turns and to keep the proper balance between directional and lateral stability. Structurally, it was desirable to confine the wing dihedral to the tip section to keep from increasing the landing gear length and to keep the spars straight between the wing-fold points.

Weapon delivery and direction systems on the Phantom II allow the launching of air-to-air missiles and ground attack stores. The fire control equipment for interceptor work consists of an infrared as well as a radar system.

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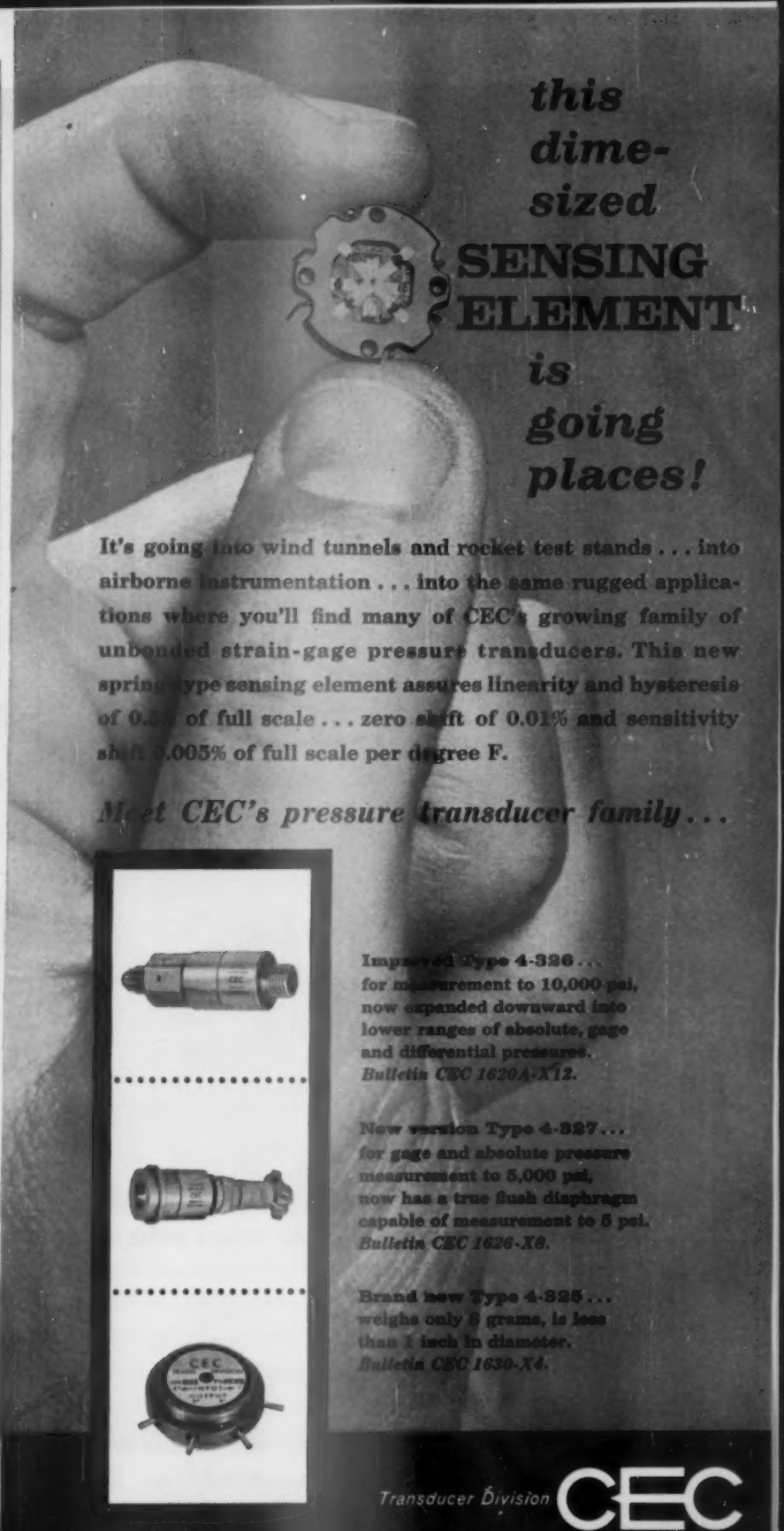
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Blasting new materials to make missile nose cones. The first ICBM nose cone ever to be recovered after flight was protected by a new, high-temperature material. Its name: Avcoite. Its construction: specially reinforced ceramic. Avcoite was the first of a family of new heat-shielding materials. They were developed for re-entering nose cones and satellites by Avco's Research and Advanced Development Division. Newest addition to this materials family is Avcoat, a plastic heat-shield here ablating smoothly in a hydrogen-oxygen jet simulating satellite re-entry temperatures.

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European F-104G Program Is Emerging

Geneva—Europe's biggest aircraft development and production program is beginning to take definite form.

A total of 774 Lockheed F-104G Super Starfighters, their spares, avionic systems, General Electric J79 powerplants and spare engines now are scheduled to be built in a sprawling complex of European aircraft factories only a half-hour's subsonic flight from the Iron Curtain.

Production Breakdown

Production breakdown will be about evenly divided between a southern group of factories in Germany and Belgium, and a northern group of German and Dutch collaborators. Target figure of 774 airplanes, used for planning purposes, was originally based on West Germany's firm figure of 574 plus 100 each for Belgium and the Netherlands. But this figure may need adjusting in view of these recent events:

• **Belgian official announcement** that their procurement of the F-104G will be limited to 50 airplanes this fiscal year, paid for with money siphoned off from other projects. Next fiscal year will see a firm order for 50 more with new funds specifically earmarked for the purpose.

• **Dutch contract with Lockheed** for the license rights for 50 airplanes. Germans had the license with Lockheed exclusively in Europe, but for political reasons waived those rights when the Dutch and Belgians were making their decisions. Observers believe the Dutch signed directly with Lockheed simply as a gesture, and will get all the airplanes directly from the European production program. Additional orders to a total of 200 are expected, but the Dutch have made it clear that any number over 50 will depend on U.S. aid.

• **Italian choice of the F-104G** in principle. Numbers have been reported anywhere between 25 and 100, but the larger figure is a realistic minimum estimate of the air force requirement. Any Italian order would probably depend heavily on U.S. aid and on the use of Italian industrial capacity in the program.

• **Reports of slippage** at this early stage in the program, which have led some Germans to start looking for alternate sources of production. One group has been talking with Fiat, presumably interested in working out a program of Italian production in exchange for an order. Others believe it may be necessary to increase the current order of 30 trainers and 66 fighters now being built at Lockheed's Burbank plant.

Plans developed for F-104G production in Europe center on the three countries currently buying the airplane: West Germany, Belgium and the Netherlands. Further, they appear to have been flexible plans, drawn up with the original German order for 210 airplanes as the basis, and extended as other orders were placed.

There are three assembly plants, one in each country, and groups of subassembly and component plants, also in each country. For administrative reasons, the grouping breaks down into two units, each with about the same total number of airframes to deliver, and each with exactly the same rate of full production.

Messerschmitt will be prime contractor for 399 complete airframes to be produced by the southern group of German companies—Dornier, Heinkel, Messerschmitt and Siebel—and Sabca and Avions Fairey in Belgium. This group will have two final assembly plants: Messerschmitt, which will assemble the 210 airframes of the original German order, and Sabca, which will put together 189 airframes, of which 100 are for Belgium and 89 for Germany.

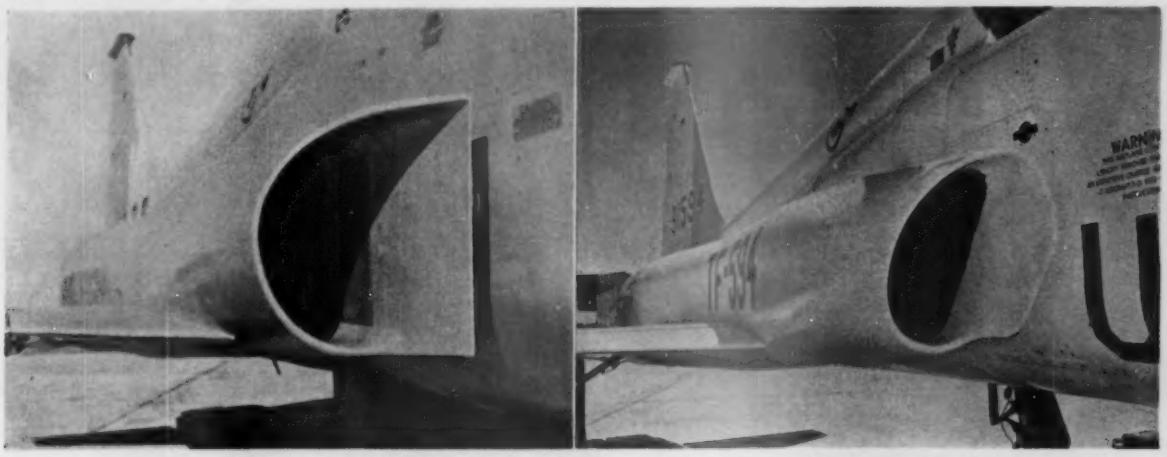
Fokker in Holland will be prime contractor for the 375 airframes to be built by the northern group of companies: Focke-Wulf, Hamburger Flugzeugbau and Weserflug in Germany and Fokker and Aviolanda in Holland. All of these airplanes—275 for Germany and 100 planned for the Dutch—will be assembled at the Fokker factory.

Many of these plants will be furnishing components to others in the production scheme for incorporation in a subassembly or final assembly. Belgian plants will be producing some components for the full production run of the southern German group, and will in turn be receiving some of their subassemblies from the German companies. Dutch factories will also be supplying the Belgian line. These crossflows are typical of the entire production scheme, rather than specifically applied to the Belgian phase of the program.

Production Rate

Production rate is geared to reach a figure of 13 airframes per month from each group or a total of 26 F-104Gs per month delivered to the Luftwaffe.

Current estimated price for the plane breaks down into approximately $500,000 for the airframe, $250,000 for the engine, $275,000 for the avionic gear



Inlets Contrasted on Northrop N-156F, T-38

More sophisticated inlet design is in use for the Northrop N-156F light strike fighter (left) in contrast to the inlet for the T-38 Talon supersonic trainer from which it is developed. Larger N-156F inlet includes perforated section for bleeding boundary layer air into a plenum chamber from which it is exhausted between intake and fuselage.

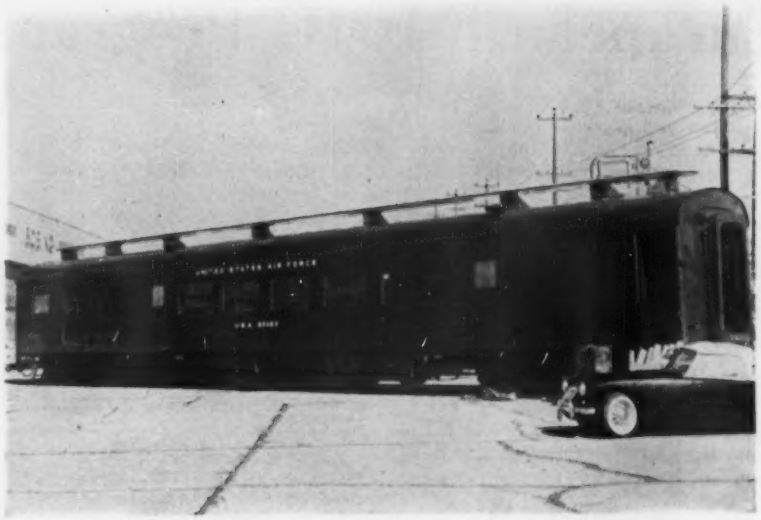
and $150,000 for other equipment.

Although airframe production is reasonably well settled for the moment, sources close to the program say that the engine situation is not so clear. Best current breakdown gives 60% of the J79 license production to BMW Triebwerkbau GmbH, and 40% to the Belgian National FN works. No specific numbers have yet been tied to this phase of the program, for two reasons: nobody knows how many engines will really be needed, and nobody is willing to say how soon either factory could be in production.

Avionics Procurement

The avionics system of the airplane, which is completely new for the F-104G and untried as a system, will be procured in fairly large quantity directly from the manufacturers in the United States. North American's NASARR fire-control system, Litton Industries' inertial navigator and other components are currently planned for purchase up to 100 units. Further numbers of the systems will be purchased in component form, according to German sources, and after that, "materials" will be bought. It is possible that there will finally be little European participation in this phase of the program when it has settled down.

Over-all coordination of this vast program has long since slipped out of the hands of the Germans who originated the whole affair and has become an international organization. Based in Coblenz, this group is beginning to take form as an agency concerned with all the technical and international problems of development and manufacture of the plane. Representatives of the countries involved, Lockheed liaison people and a variety of working group



Minuteman Command Car Tests

Train commander's car will be the communications center during Minuteman rail mobility tests scheduled to begin June 20 (AW June 6, p. 35). Antenna on top of car was designed by Boeing Airplane Co., which is developing the mobile ICBM launch concept under direction of USAF Ballistic Missile Division for Strategic Air Command. Train will carry communications equipment and instruments to study stress and strain factors which would be expected to be encountered by operational Minuteman trains.

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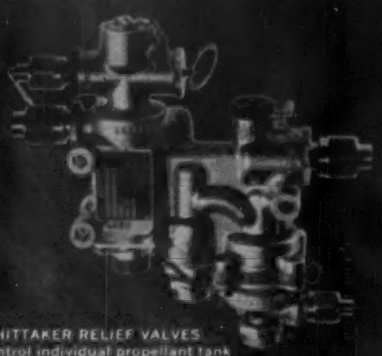

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for system components such as ground support, armament, powerplant and the like have begun to move into Coblenz to work on the across-the-board problems.

Different Airplane

Part of the difficulty in the production program for the European Starfighter lies in the fact that, except for some of its external shape, the F-104G is a new airplane.

The Lockheed Starfighter series began as an interceptor, a "hotrod" airplane with sensational performance at high altitude in good weather. The Germans wanted a multi-purpose airplane to work at all altitudes in all weather. The German version—the F-104G—is now being developed for interception, offensive strikes in a fighter-bomber role, low- and high-level visual, photographic and electronic reconnaissance and even for the highly specialized task of aerial marine reconnaissance.

Its new avionic systems include the entire navigational system with autopilot, inertial navigator and position and homing indicator; fire control system; bomb computer and air data computer.

Armament

Armament is four infrared-seeking Sidewinders. External stores include extra tankage, reconnaissance pods and presumably special weapons of all varieties.

Fuselage-wing intersection has been beefed up because of increased loads applied during low-level missions. Thirty-six new forgings have been designed for wing fittings and beams for fuselage main frames, longerons, joints, tail frames and some skins, and for empennage beams and ribs. The tail group has been modified; the vertical tail has 25% more area, the rudder is powered and features both yaw damping and directional control on a single surface.

Interchangeable fuel tank and armament system has been developed for the German Starfighter. The space provided in the original design for the General Electric 30-mm. Vulcan cannon, its ammunition, case and link collector boxes, has been used for special aluminum tanks giving 120 gal. of extra fuel.

Either tank or gun installation can be made in the field.

Missile Mounts

A wingtip-mounted pair of Sidewinder missiles has been augmented by an additional set of two mounted on the fuselage belly. For long range interception the belly missiles are retained but the wingtip rounds are replaced by tip tanks and additional pylon-mounted wing tanks are carried.

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Scientists at Grand Central Rocket Co. have enormously widened the margin of advantage of the solid propellant over liquid, in *practical* application,

with development of a new high-energy nitrocellulose-aluminum perchlorate solid propellant named Nitrasol—now in pilot production at GCR.

In March a completely case-bonded, cast-in-place missile motor of Nitrasol was temperature-cycled repeatedly from minus 75°F to plus 165°F and then successfully fired at minus 68°F. Such motors have excellent storage characteristics. They can be stored for extensive periods, then fired at an instant's notice.

These qualifications adequately fulfill the conditions of environmental storing, handling and tactical deployment which the military services would ideally hope to specify but which until now have not been realized in any high-energy propellant.

High production rates in a low cost facility make Nitrasol even more attractive. The four ingredients are easily and safely combined; organic nitrate plasticizer-stabilizer solution, fine-particle nitrocellulose, ammonium perchlorate and aluminum particles.

The feasibility of mixing Nitrasol in GCR's Redlands plant and transporting it to any location in the U.S. for subsequent casting in large-volume solid motors is yet another possibility of Nitrasol—perhaps the most promising propellant in existence today.

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tics Division's NASARR fire control system will provide both air-to-air and air-to-ground modes of operation including data link information read out.

The infrared sighting system is being developed to be compatible and integrated with the conventional director sight of the NASARR equipment. This is expected to give increased detection range under daylight conditions.

Bombing computer gives the pilot a choice of four modes of attack, all automatic: level flight, dive-toss, LABS (low-altitude bombing system) and over-the-shoulder. The last two are keyed to delivery of special weapons from low-level high-speed passes.

Position and homing indicator is an automatic dead-reckoning navigator which continuously computes present position based on initial position and corrections made for speed and course alterations. The pilot gets a presentation of course and distance to target, eliminating, it is hoped, the need for cockpit map reading and navigation. The unit is being developed by Computing Devices of Canada.

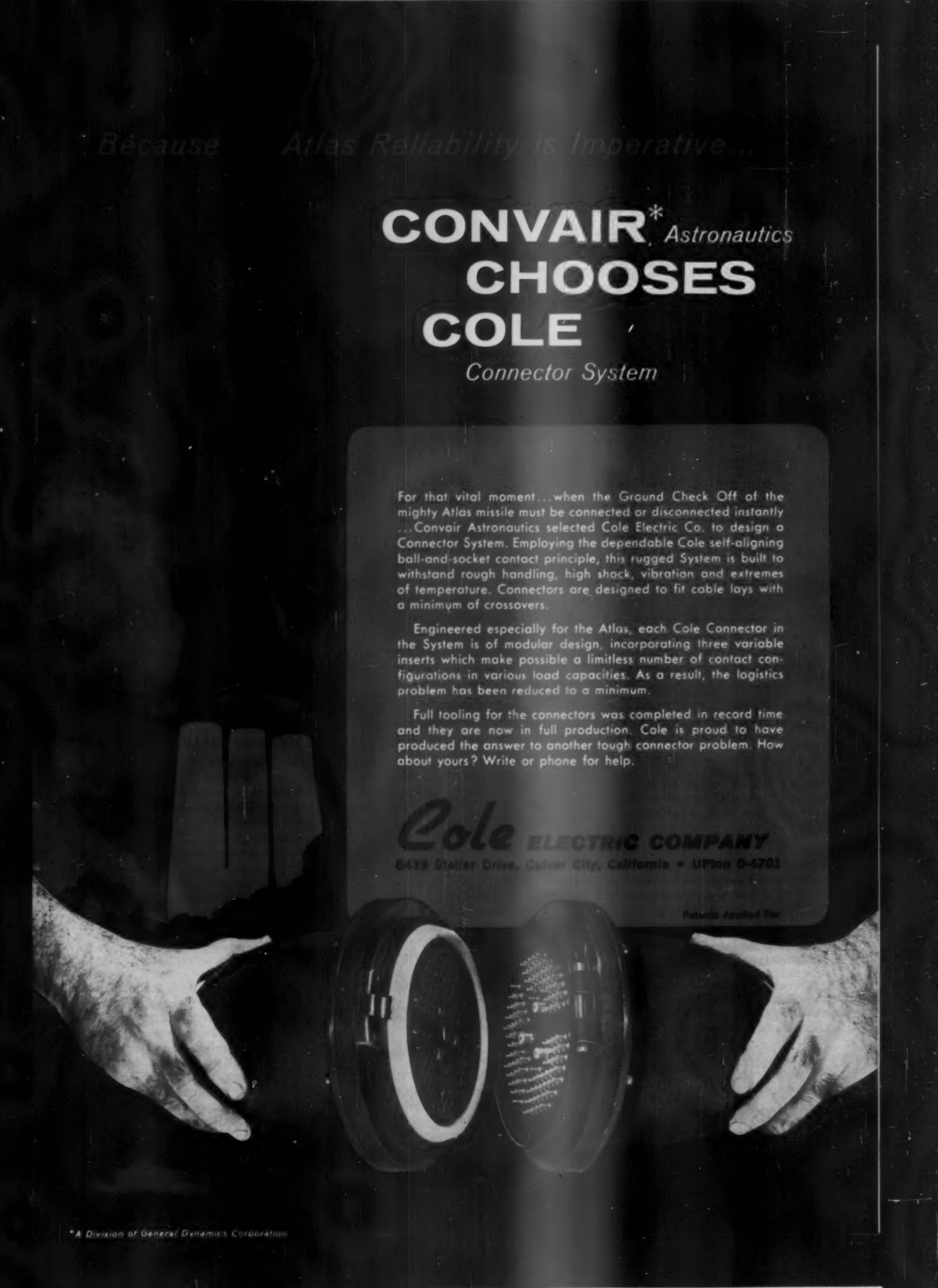
Inertial navigational system, being developed by Litton Industries, is a new lightweight unit which measures ground distance and track of the flight.

Flight Testing

There seems to be a complete blank in the over-all project under the heading of flight testing, at least so far as the European contribution goes. The F-104G design itself will be tested, both in subsystem form and as a complete weapon, at Lockheed's Burbank or Palmdale facilities in California. German, Canadian and U.S. pilots will participate, but the U.S. pilots will be solely advisers. Evaluation flights as a weapon system will be made at Edwards AFB, Calif., again with USAF advice only, and the Germans this time retaining sole authority on final decisions. Final testing in simulating combat as-

B-52 Windshield Rain Test Device

Rain machine used by Chance Vought engineers to study rain film problem on Boeing B-52 windshields has 16 hypodermic needles mounted vertically (right) to spray various sized droplets at high speed on mockup windshield.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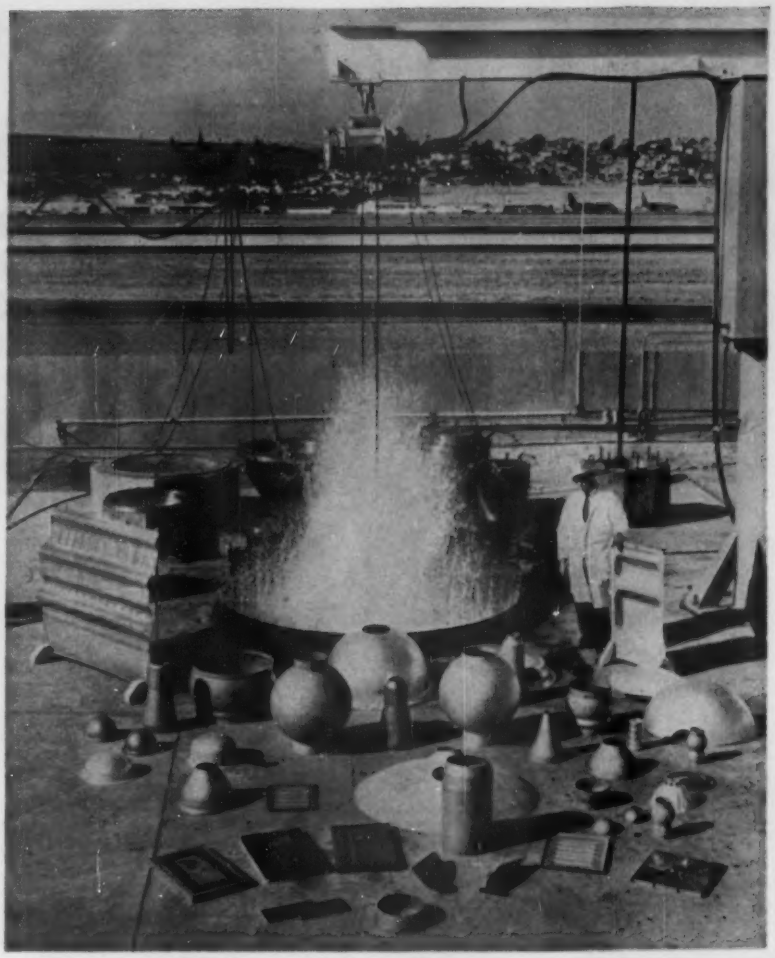

Ryan Builds Explosive Forming Installation

Ryan Aeronautical Co. has built an explosive forming installation at San Diego, using detonation in a water-filled pit (note geyser) to form variety of shapes in foreground. Parts include rocket chambers, pressure vessels, radar reflectors, JATO bottles and others. Company also will use system at Watertown, Mass., to test explosive forming of aluminum, titanium and stainless steel alloys, under U. S. Army contract.

signments will make up the third stage of flight testing; this work will preferably be done in Germany.

Details of acceptance flight test work on each of the airplanes produced have not yet been ironed out. None of the companies involved in the program has a flight-test facility which includes enough ground support systems to handle final testing of any modern airplane. Automatic receiving equipment for telemetered flight data is not available; company airports are not all-weather fields.

Traffic control systems, ground-based navigational aids and the usual welter of associated ground equipment are almost completely lacking on the list of group facilities.

The only long hard-surfaced runway in the southern group of companies belongs to Dornier at Oberpfaffenhofen, where the company overhauls the Luftwaffe's Canadair Sabres. But the runway couldn't handle the F-104G in marginal weather or any emergency, and consequently Dornier is getting the final assembly and flight test for the Fiat G.91 lightweight strike fighters.

First Airframe

Time is running fast on the program. The first F-104G airframe less its avionic systems, and therefore not a prototype weapon, is due to make its first flight in September. The first few F-104F two-seat trainers have been delivered in Germany and the six-man pilot team which trained on the planes in the United States is back and about ready to start training new pilots from the Luftwaffe.

These pilots—Col. Guenther Rall, Capt. Hans Flade and 1st Lts. Wolf-

gang von Steurmer, Berthold Klemm, Edmund Schulz and Bernd Kuebart—were to be joined this month by Lockheed test pilots Robert Faulkner and G. J. Guisler who are assigned to help in the basic training program in Germany.

Routine for the training flights in California called for each pilot to make 26 flights; 13 dual with an instructor, 3 with a check pilot and 10 solo. A similar curriculum will probably be adapted for the Luftwaffe's program.

Merger Is Proposed By Okanagan, Bristol

Merger of the Okanagan Helicopters, Ltd., group with Bristol Aeroplane of Canada, Ltd., a wholly owned subsidiary of Bristol Aeroplane Co., Ltd., of England, is being proposed to stockholders of both firms.

Bristol has made a cash offer of $4.50 per share for Okanagan stock, or in lieu of cash a possible stock-and-cash or stock exchange.

Bristol of Canada owns or controls 48% of Spartan Air Services stock now, and has made an offer to Autair, also a helicopter operator. Spartan operates helicopters and has an air survey operation.

Combination of Okanagan, Autair and Spartan would result in two divisions of Bristol of Canada—one for the helicopter operation, where the Okanagan name would probably be retained, and another for the air survey operations, where the Spartan name would be retained. The combined company would have approximately 100 aircraft.

Companies Form R&D Nonprofit Bid Team

New York – Seven technical companies have formed a nonprofit technical bidding organization – The New York Research and Development Team –which will specialize in electronic, nuclear, chemical and mathematic activities.

According to Cyrus Adler, president pro tem, the team is made up of seven core companies located in the metropolitan New York area which have a combined sales volume in excess of $4,000,000 annually. The heart of the team is a working force of over 300 employes, of which more than 100 are scientists and engineers who have been concerned with research projects in many areas of technical specialization.

Members of the New York R&D team are: Aerolite Corp., Union City, N. J., electronic component manufacturer; Computech Corp., New York, data processing and computing; Glenn

Aircraft Missile manufacturer alternator test stand control center housed in . . .

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Alternator test stand control center Consoles are housed in standard EMCOR Cabinets.

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Outstanding test performances are being registered by the WESTINGHOUSE ELECTRIC CORPORATION alternator test stand installation at NORTH AMERICAN AVIATION, Columbus, Ohio, housed in EMCOR Cabinets. Westinghouse test stands permit accurate simulation and evaluation of voltage regulations transient response, overload capacity, paralleling operations and shock loading for testing alternators or for complete aircraft/missile electrical systems. EMCOR Engineering "know-how" in metal cabinetry keeps pace with the packaging requirements in missile testing, firing and tracking equipment. Costly custom cabinet design time is eliminated with a choice of over 600 basic frames in the EMCOR MODULAR ENCLOSURE SYSTEM. Write for complete details.

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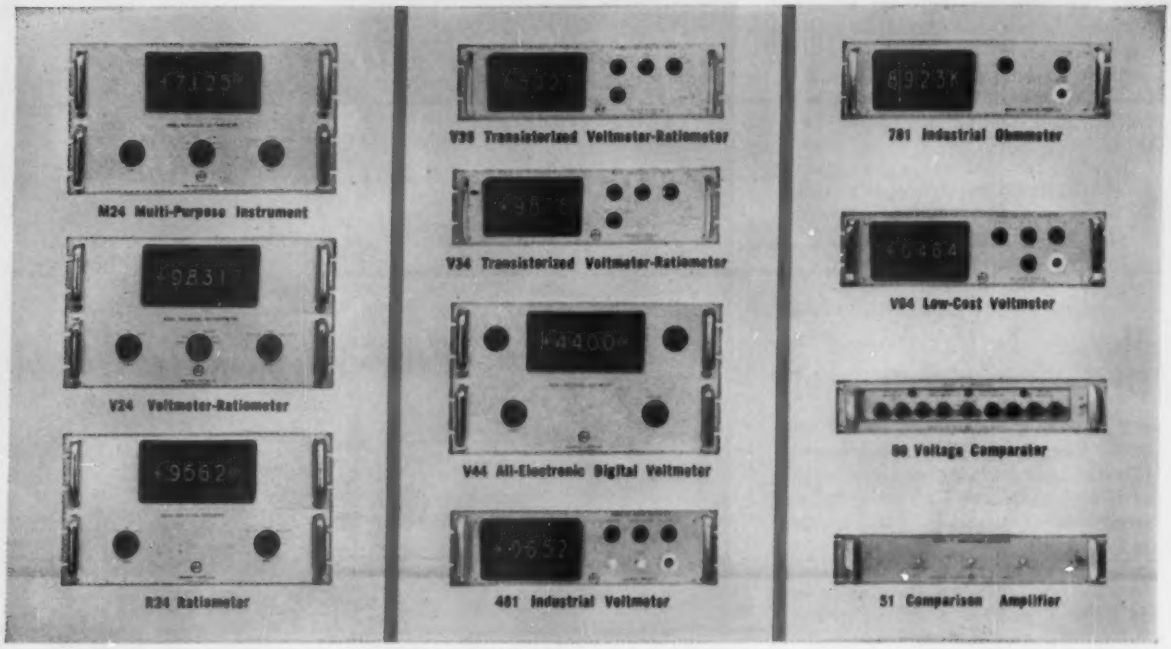

NLS OFFERS YOU THE ONLY COMPLETE LINE OF DIGITAL INSTRUMENTS...BY PURPOSE...BY PRICE

M24 Multi-Purpose Instrument — Measures DC voltage from ±.0001 to ±999.9, DC voltage ratio to ±.9999, resistance from 0.1 ohm to 1 megohm . . . 1/3 second balancing time . . . with accessories, measures AC voltage or AC ratio, low-level DC . . . completely automatic . . . output for data logging . . . transistorized circuitry, mercury-wetted relays . . . recommended for measuring and data logging demanding best combination of reliability, accuracy, speed and versatility — missile systems checkout, industrial electronic systems, unattended data logging, quality control, laboratory uses. **Complete $5,650**

V24 Voltmeter-Ratiometer — Same basic features, specifications and applications as the M24 except it does not measure resistance. **Complete $4,950**

R24 Ratiometer — Measures DC ratio with ranges of ±.9999/9.999 . . . same basic features and applications as M24 and V24. **Complete $4,650**

V35 Transistorized Voltmeter-Ratiometer — This all-transistorized instrument is the first true 5-digit voltmeter with the Factual Fifth Figure, full 5-digit resolution of 0.001% . . . measures DC voltage from ±0.0001 to ±999.99, DC voltage ratio from ±00.001% to ±99.999% . . . with accessories, measures AC voltage low-level DC . . . completely automatic . . . features No-Needless-Nines logic, plug-in oil-bathed stepping switches . . . output for data logging . . . recommended for uses requiring maximum accuracy such as automatic missile checkout; production line inspection of transistors, resistors, diodes; readout and printout for computers. **Complete $3,750**

V34 Transistorized Voltmeter-Ratiometer — 4-digit quality and performance companion to V35 — with No-Needless-Nines logic, plug-in oil-bathed stepping switches and full transistorization . . . measures DC voltage from ±.0001 to ±999.9, DC voltage ratio from ±00.01% to ±99.99% . . . with accessories, measures AC voltage, low-level DC . . . output for data logging . . . designed for uses requiring Series 30 reliability without the need for full 5-digit resolution. **Complete $3,150**

V44 All-Electronic Digital Voltmeter — 500 readings per second . . . measures DC voltage from ±0.0001 to ±999.9 . . . completely automatic . . . output for data logging . . . recommended for applications in which exceptionally high speed is essential. **Complete $6,500**

481 Industrial Voltmeter — This 4-digit instrument is an outstanding value for applications requiring 0.01% accuracy at lowest cost . . . designed for visual readout only, does not contain printout connections or oil bath switches . . . features simple, time-proved 7-tube circuit . . . measures DC from ±0.001 to ±999.9 — AC and low-level DC with accessories . . . for applications requiring 0.01% accuracy without printout — production testing, instrument calibration, laboratory testing, receiving inspection. **Complete $1,425**

781 Industrial Ohmmeter — Companion to the 481, this 4-digit ohmmeter equals the performance of other units costing twice as much . . . measures 0.1 ohm to 10 megohms . . . accuracy of ±0.05% + 1 digit, ±0.1% of reading above 5 megohms . . . 20 times faster than using a Wheatstone bridge . . . completely automatic . . . used for fast, easy resistance measurements not requiring printout, such as receiving inspection, production, quality control, laboratory testing. **Complete $1,425**

V84 Low-Cost Voltmeter — Only full 4-digit voltmeter in the price range of 3-digit meters and laboratory quality pointer meters . . . measures DC voltage from ±0.001 to ±499.9 . . . AC and low-level DC with accessories . . . features quality NLS construction, design simplicity, time-proved circuitry . . . designed for measuring applications that require the speed, ease, and accuracy of a digital voltmeter without the need for printout or automatic range-polarity selection . . . applications include transducer and test equipment calibration, quality control, production line and receiving inspection, laboratory uses. **Complete $985**

90 Voltage Comparator—This transistorized go/no-go voltage comparator provides a precise, fast, reliable means to determine if a voltage is within prescribed limits—and to transmit go/go-no commands to electrical recording control and warning systems . . . signals voltage tolerance by colored bulbs and contact closures within 90 milli-seconds . . . manual limit settings from ±0.001 to ±999.9 volts. **Complete $1,775**

51 Comparison Amplifier — Automatic comparator model for applications where limits are already available in analog voltage form from fixed or automatically programmed voltage dividers . . . voltage range from −50 volts to +50 volts with a limit sensitivity of 500 microvolts. **Complete $950**

Hundreds of Combinations

A wide range of accessories are available from NLS for easy, plug-in combination with the basic units pictured. This provides you with several hundred combinations from which to select the grouping which best answers your measuring and data logging problems.

- AC/DC Converters with or without automatic ranging
- AC Reference Voltage Converter for AC ratio measurement
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For Additional Information . . . contact your nearest NLS representative or write NLS for complete catalog section on specific instruments of interest to you. Specifications and prices are subject to change without notice.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR (SAN DIEGO), CALIFORNIA

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Associates, New York, engineering service; Manhattan Physical Research Group, Inc., New York, technical research and consulting; New York Testing Labs, New York, general electronics and chemical testing; Stratos Missiles, Inc., New York, systems engineering and research; Radiation Research Corp., New York, nuclear engineering and research.

The New York R&D team has applied to the Small Business Administration for approval and will function as a nonprofit bidding organization concentrating on both military and commercial research and development activities.

Mr. Adler, who is also president of one of the core companies, Manhattan Physical Research Group, Inc., announced that the team will expand. In addition to considering recent applications from several additional companies, the group is interested in receiving inquiries from other technical firms who may wish to join in this activity.

The offices of the New York R&D team are located at 150 Broadway, New York.

Japanese Company May Build Lacrosse

Tokyo—The six companies composing the Mitsui Group, Japan's largest trading corporation, have decided to establish a firm called the Japan Rocket Manufacturing Co. which may eventually produce the Martin Lacrosse guided missile under license. Initial capitalization would be $300,000.

Toshiba, one of the six companies responsible for organizing the new firm, said the date of establishment is undecided pending completion of the Japan Self Defense Agency's current defense buildup program. The agency is fighting to boost its Fiscal 1960 budget to at least twice the approximately $800,000 it has been receiving annually for the past three years.

Japanese defense authorities recently concluded that the Raytheon Hawk and Martin Lacrosse missiles are best suited to fulfill Japan's missile requirements. The Mitsui Group, which handles almost one third of Japan's exports, is Japanese agent for the Martin Co.

Present plans call for Mitsui to divide responsibility for missile weapon system production among its six companies as follows:

- **Toshiba**—electronic components.
- **Fuji Heavy Industries**—missile airframes.
- **Dainippon Celluloid** and Tokyo Keiki—automatic measurement instruments.
- **Nippon Seiko**—warheads and ground support facilities, including missile launch pads.

CLEMCO
AERO PRODUCTS, INC.

LINEAR and ROTARY ACTUATORS

are IMPERVIOUS to

HEAT and RADIATION

LONG STROKE RADIATION RESISTANT LINEAR ACTUATORS

The Clemco Aero Products radiation resistant linear hydraulic actuator was designed for the coarse control of an atomic engine which uses a Clemco Aero Products rotary hydraulic actuator for the vernier control.

This is a double ended unit with a piston area of .44 square inches and a 40 inch stroke for operation in a 3000 P.S.I. hydraulic system. Snubbing is provided for the final two inches of stroke in both directions.

All materials with the exception of the low pressure seals, which are asbestos graphite, are inorganic. The high pressure rod seals are an all metal segment type, and the piston is sealed with metal piston rings. Internal leakage at a pressure differential of 3000 P.S.I. is less than .15 G.P.M. Pressure to start motion is 60 P.S.I.

The basic design and materials used in this unit render it applicable for high temperature as well as radiation resistant uses.

TEMPERATURE AND RADIATION RESISTANT ROTARY ACTUATORS

The basic design of the extremely efficient Clemco Aero Products Rotary Hydraulic Actuator is readily adaptable to applications requiring operation under conditions of high temperature and or radiation.

The vane and abutment seals do not rely on elasticity to perform their function so the material choice is almost unlimited. Efficiencies better than 90% are attained even though the coefficient of friction of the inorganic materials used is considerably greater than the teflon used in the standard Clemco Aero Products rotary actuator, and internal leakage and backlash can be held to very small values.

Viton A "O" rings are excellent external seals for applications where temperatures do not exceed 500° F. and radiation is not present. For higher temperatures and or radiation, the rotating output shaft lends itself to the use of metal bellows face seals which are considerably more efficient and reliable than any of the all metal seals developed for reciprocating output rods to date.

In applications where an appreciable difference between ambient and fluid temperatures exist, the rotary actuator output shaft does not move from the ambient temperature into the fluid as does the output rod of a linear actuator. This action in a linear actuator prevents temperature stabilization as well as penalizing the fluid.

The Clemco Aero Products rotary actuator also operates satisfactorily when hot gas is the fluid medium.

CLEMCO AERO PRODUCTS, INC., THE WORLD'S LEADING PRODUCER OF PROVEN ROTARY TAS AND FLUTTER DAMPERS, ALSO FURNISHES THE LEADERS OF THE AIRCRAFT AND MISSILE INDUSTRY WITH:

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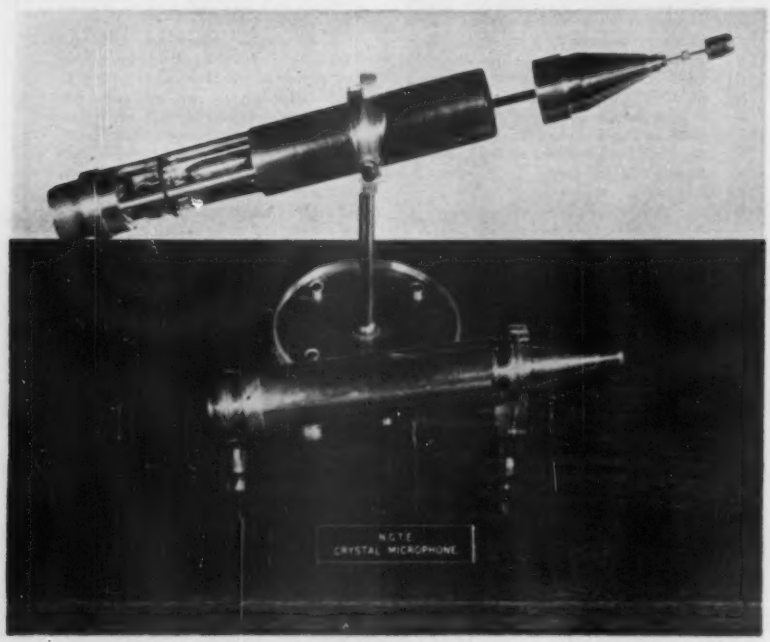
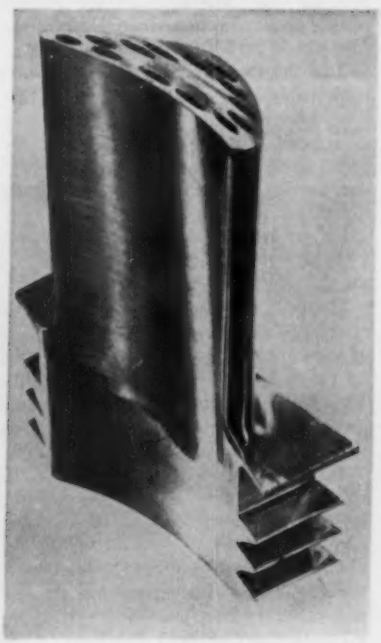
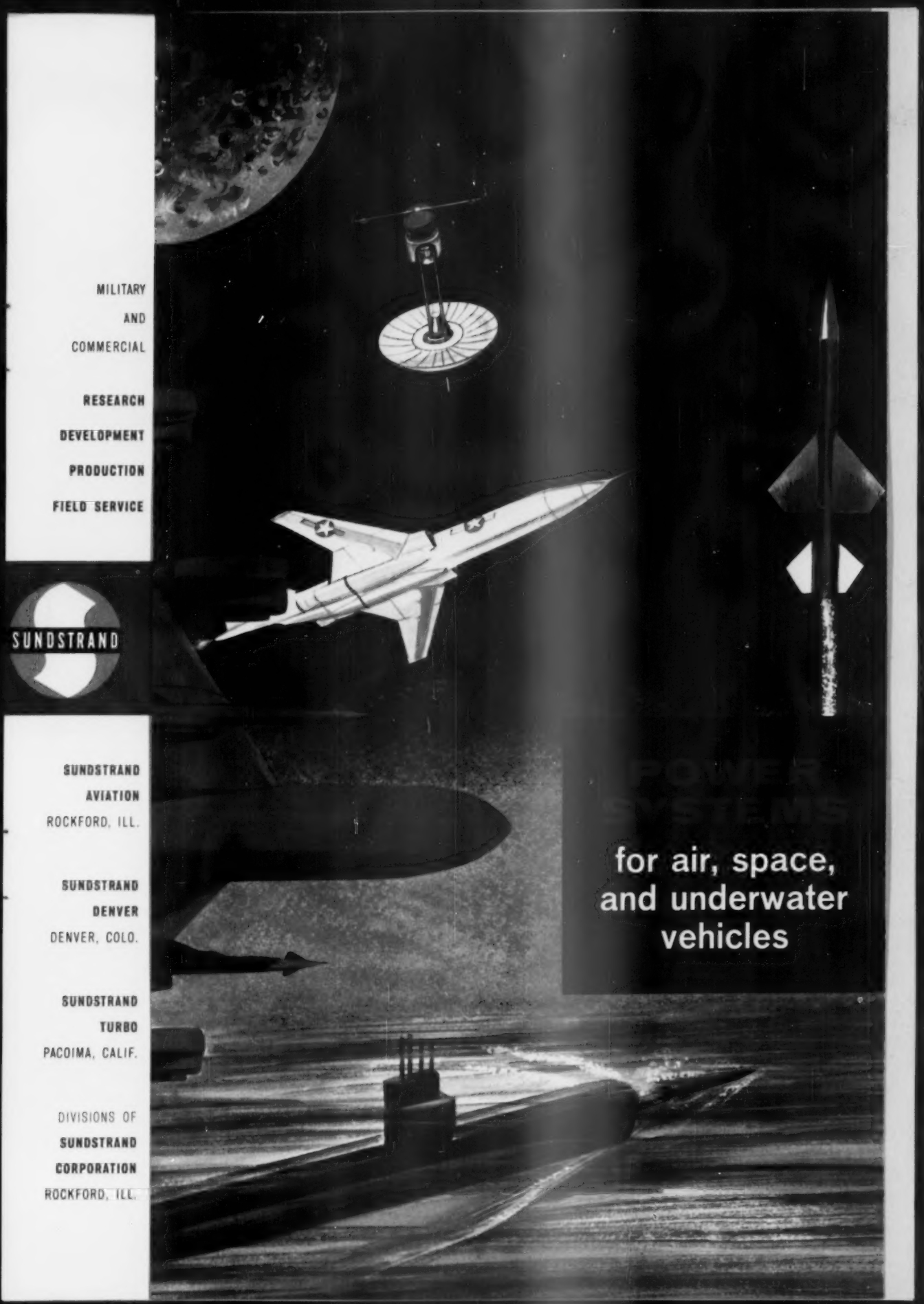
Britain's National Gas Turbine Establishment at Pyestock, near Farnborough, England, is constructing a 20-ft.-dia. engine test cell. End dome of the test cell is shown at left. The control room for the cell (above) is equipped for fully automatic data handling. The test cell has eight compressor banks. Each bank consists of three compressors in series driven by a 36,000-hp. electric motor. Steam turbines are used for starting.

British Construct 20-ft.-dia. Turbine Test Cell





Jet noise investigation at the National Gas Turbine Establishment has shown a relationship between noise levels and annoyance factors. Special lead zirconate crystal microphone (left), used in these noise studies, can measure high sound levels at 26 kilocycles per second. The Establishment has found that turbofan engines show a 20% decibel reduction and it is expected that a further 20% reduction can be achieved. Aircooled blade for military gas turbine is shown at right.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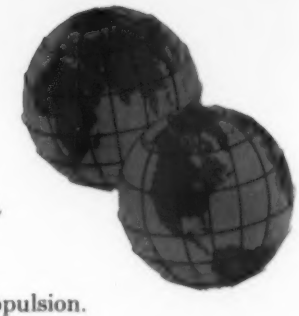

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Three Sundstrand divisions are working together to provide continuity of research, development, and manufacturing in the field of power systems and components . . . electrical . . . mechanical . . . hydraulic . . . fluid transfer . . . energy conversion . . . propulsion.

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Sundstrand experience and capability encompass creative concepts, product-oriented research, systematic development planning, precision production, effective service, and complete systems management.

Detailed information is available upon request. Write or call the nearest Sundstrand facility or field office: Arlington, Texas; Hawthorne, California; Rockford, Illinois; Dayton, Ohio; Seattle, Washington; Stamford, Connecticut; Washington, D. C.

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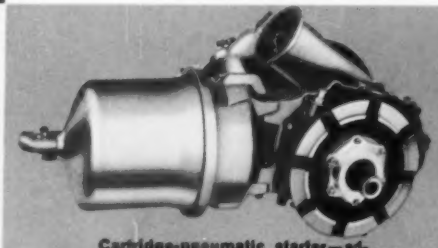
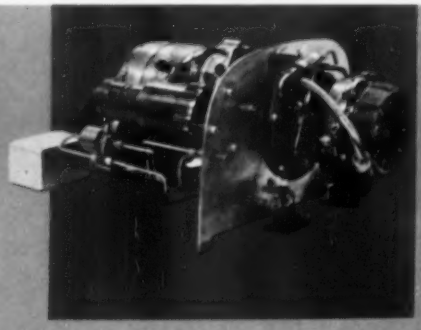
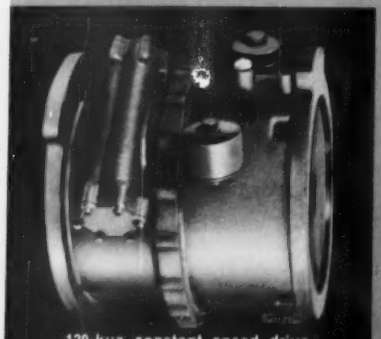


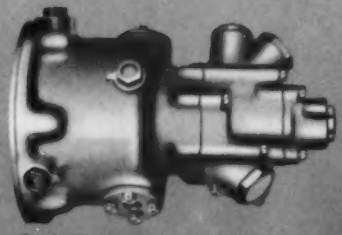
Cartridge-pneumatic starter—advanced three-way jet engine starting . . . cartridge solid propellant, cross bleed air, and low-pressure ground cart air. Aerodynamic braking prevents overspeeding. Cascade safety features insure fail-safe operation. Readily adaptable to most aircraft.



Orbital vehicle power supply—open cycle, chemically powered through pressure-staged turbine. Duty cycle 4.5 hours; 960-hp-seconds/lb specific horsepower.

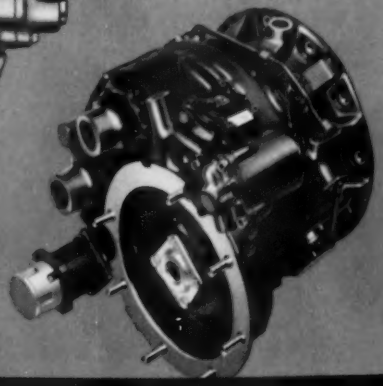


120-kva constant speed drive—provides the increased power required by new aircraft, such as the B-52H. Sundstrand drive applications cover 10, 20, 30, 40, 60, and 120-kva requirements.



Controlled speed hydraulic motors—throttling losses are minimized by these variable displacement motors, which drive the generator for the Hound Dog missile.

F6U-3N a-c electric system—provides reliable constant frequency power for automatic flight controls, radar, and instrumentation for all-weather operation.



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Co-ordinated facilities in three strategic locations:

SUNDSTRAND AVIATION — Rockford, Illinois

. . . originator of the first successful aircraft constant speed drive and the nation's leading supplier of aircraft secondary power systems and components.

Sundstrand Aviation has delivered more than 28,000 constant speed drives for 39 major classes of military and commercial aircraft. They are currently serving North American Aviation as secondary power subsystems manager for the B-70 mach 3 intercontinental bomber.

The Aviation Division has developed an aircraft constant frequency electrical system capable of 600° F operation . . . a program which involved comprehensive evaluation and complete environmental testing of all mechanical, hydraulic, and electrical components.

New product concepts originated and supported include an advanced cartridge-pneumatic jet engine starter and a combination starter-drive.

Sundstrand Aviation's facilities include industry's most fully equipped environmental testing laboratories for secondary power systems.

SUNDSTRAND DENVER — Denver, Colorado

This division's scope includes research, development, and manufacturing of totally new accessory products for military and commercial applications.

Work is being conducted in hydrodynamics, cryogenics, fuel pumping, hydraulics, and related fields. The most recent development is the Sundyne pump described below.

The Denver plant is fully equipped for both prototype manufacture and volume production of hardware involving the most critical tolerances. Laboratories and test facilities meet all requirements for quality control and checkout of precise components.

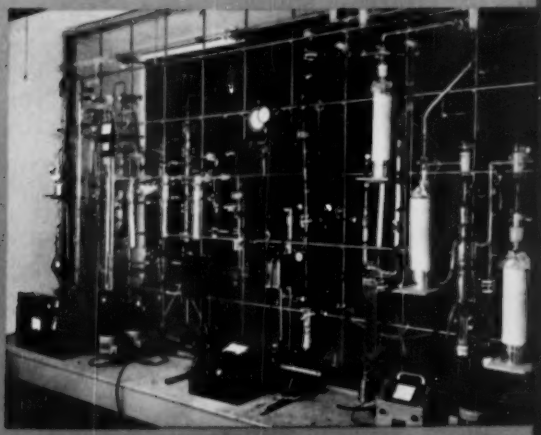
SUNDSTRAND TURBO — Pacoima, California

This division is engaged in research and development related to advanced power generating systems for underwater, surface, air, and space vehicle applications. Recent completion of new facilities provides increased capabilities for prototype manufacturing and test engineering.

Current work includes testing the most advanced chemically fueled flight vehicle power unit in the free world . . . development of a dynamic solar engine for electric power generation on space vehicles . . . development of a family of advanced bearings lubricated by cycle working fluids . . . determination of rational rocket scaling methods to obtain useful design information for development of large engines . . . research and development of high-efficiency, advanced torpedo propulsion systems.

Sundstrand Turbo offers unusual capability in turbine analysis and design . . . extensive experience in handling and using high-energy fuels . . . unparalleled knowledge of closed-cycle turbine systems with advanced working fluids . . . comprehensive abilities in photochemistry. Extensive environmental test facilities including high altitude chamber and centrifuge provide unique support for all programs.

New combination starter drive for turbine engines—combines electric starting and a-c power generation in one system, saves costs and weight, permits starting from electric outlet instead of bulky compressed air equipment.



Solar regenerative fuel cell under development—for one year continuous operation at 500 watts, 28 volts d-c.

Sundyne pump—a unique centrifugal pump with metering capabilities developing very high pressures in a single stage, driven at high speeds, and featuring negligible temperature rise during continuous dry operation. Above application is for water injection in turbofan models of Boeing 707-120B jetliners.

Flight attitude control system—for directional control of manned space vehicles and positioning of unmanned payloads.

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new actuator 50% smaller in size...55% less weight

Assignment: Take the present size actuator (silhouette below) that operates a 2½" butterfly valve. Squeeze it down as far as you can with no sacrifice in performance. Result: The new Barber-Colman NYLC actuator (inside of silhouette) that reduces volume 50%, weight 55%. And it fulfills all previous high-speed torque requirements for the application. Even with these size-weight reductions, this new actuator meets all applicable military specifications. For today's aircraft and missile requirements, Barber-Colman actuators are available in a wide range of sizes and characteristics. Consult the Barber-Colman engineering sales office nearest you: Baltimore, Boston, Fort Worth, Los Angeles, Montreal, New York, Rockford, Seattle.

CHARACTERISTICS NYLC ACTUATOR

Breakaway torque — 35 lb-in.

Continuous load — 25 lb-in.*

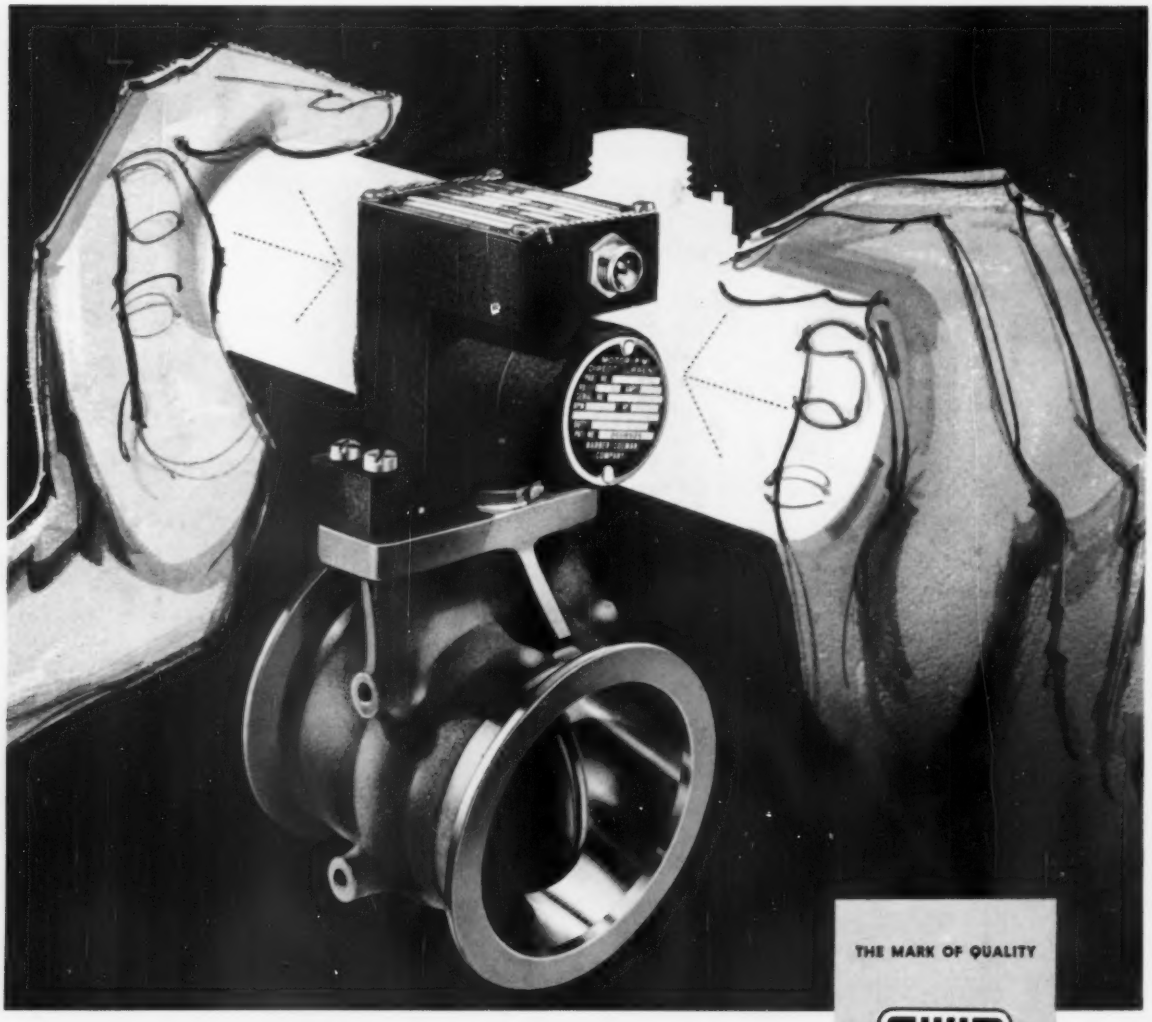
Travel limit — 320°.

Temperature range — minus 65° F to plus 250° F.

Weight with radio noise filter — 0.75 lb.

Size — 2⅛" l, 2¼" h, 1⅛" w.

*Rating can be increased to 100 lb-in with addition of ½" height and 0.2 lb weight



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STOL C130B has landed within 450 ft., but test pilots feel it can land in shorter distances. Low level testing was done at Palmdale, Calif.

Lockheed Applies BLC to Large Aircraft

By J. S. Butz, Jr.

Washington—Flight test of the C-130B STOL transport with blowing-type boundary layer control indicates Lockheed has applied this type of high lift system successfully to a large aircraft and has avoided the three primary problems which have plagued such aircraft in the past.

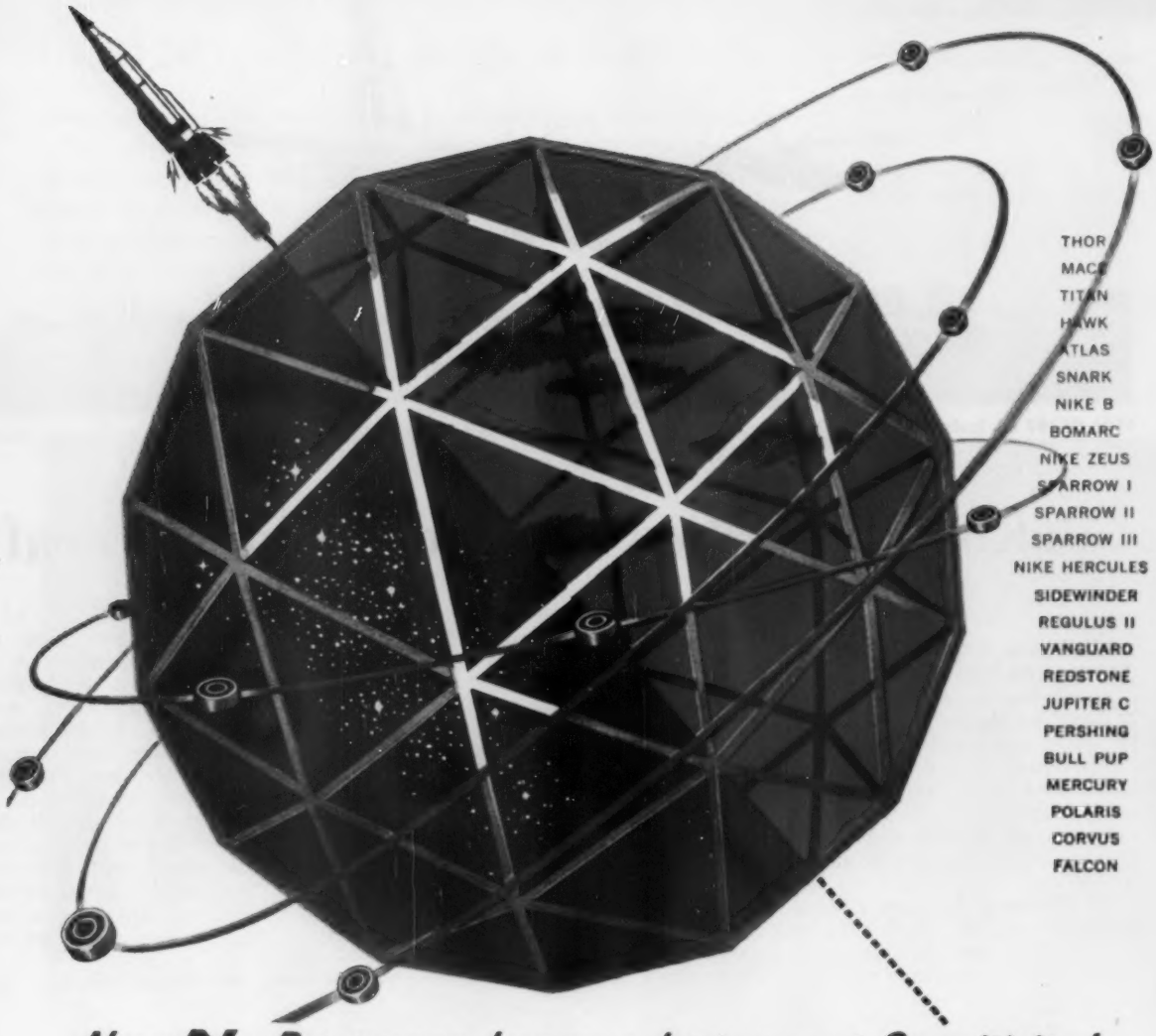
These three problems and the solutions used by Lockheed on the modified C-130B are:

• **Loss of control** during partial power failure, which was avoided on the C-130B STOL transport by using two separate turbine engines to supply air to the interconnected ducting on the blowing BLC system so that either engine alone can keep the complete system operating. On some past experimental BLC aircraft, a separate system was provided for each wing so that if one system failed, the lift on the wings was suddenly unbalanced and a large uncontrollable rolling moment was created.

• **Abrupt and violent stall** characteristics common to many BLC aircraft in the past are not experienced by the modified C-130B because a large part of its lift is obtained by propeller slipstream deflection. Boundary layer control systems generally increase lift by preventing flow separation at the wing trailing edge over a wide angle of attack range, but this advantage is usually offset by a sharp stall pattern caused by sudden and complete flow separation beginning at the leading edge. Lockheed says the modified C-130B has a gentle stall that progresses slowly through several degrees of angle of attack, primarily because the maximum flap deflection was increased to 90 deg. to obtain more slipstream lift than was possible on the original aircraft. Flight tests have indicated the full 90 deg. of flaps might not be needed.

• **Control effectiveness** generally has

BOUNDARY LAYER control Lockheed C-130B is tufted on rear fuselage for boundary layer control tests.



New ND Processes Improve Instrument Sensitivity!

In delicately-precise instrumentation, parts must react to relatively small rotive forces. Here . . . bearing torque is the highly critical factor. Separator selection, bearing finish and clinically clean assembly areas are extremely important.

It's here that New Departure is setting new industry standards! Special dies and in-process gauging of separators assure ball retention with improved torque and vibration characteristics. In addition, new N.D. honing processes and Talyrond gauging deliver uniform accuracy to millionths of an inch. Moreover, having originated the first bearing industry "white room", followed by continuous experience, New Departure's present day, modern assembly areas approach fantastic levels of cleanliness.

An everyday example of N.D.'s contribution to improved instrument sensitivity can be found in the Smithsonian Institution-selected Micro Clocks. These vitally important instruments are accurately tracking both U.S. and foreign satellite movements in time determinations of 1 milli-second . . . and better!

For new *performance* and *reliability* in your precision instruments, ask your N.D. Miniature/Instrument Bearing *Specialist* to sit in on early design level discussions. For further information call or write Department L.S., New Departure Division, General Motors Corp., Bristol, Conn.

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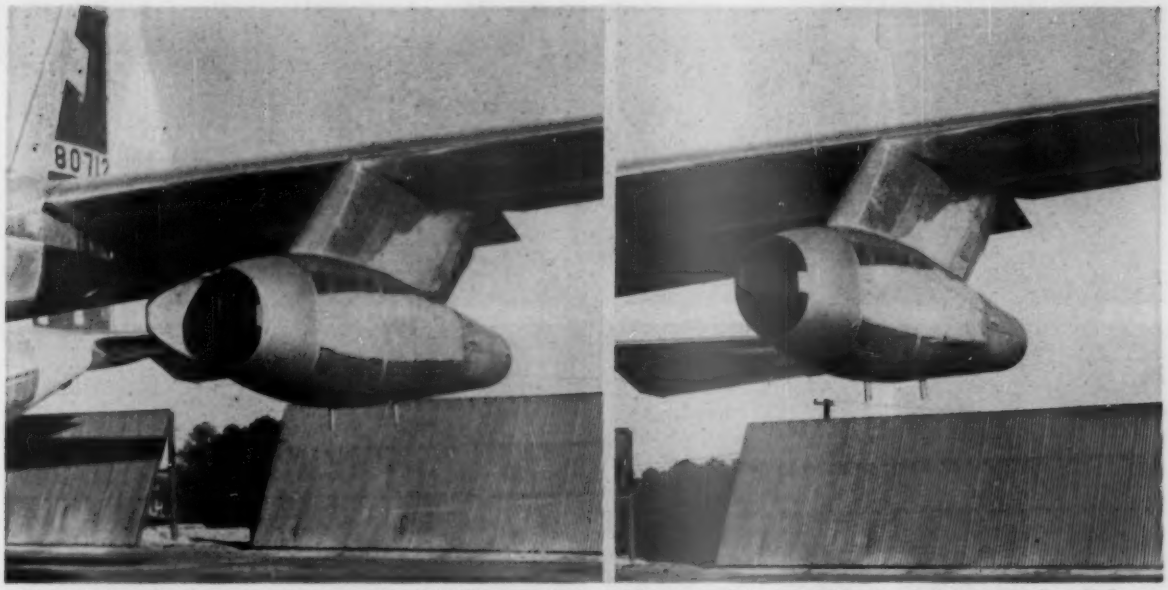
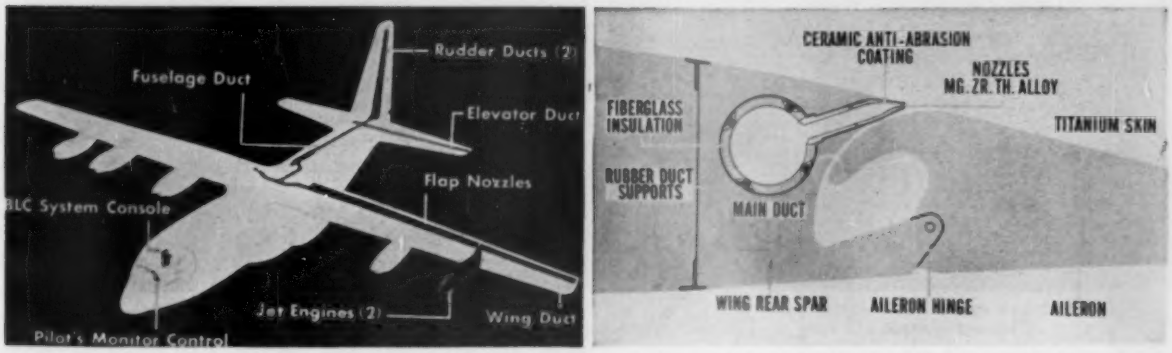


AIR for the boundary layer control system in the C-130B short takeoff and land aircraft is supplied by two turbojets in pods. (Pod open at left, closed at right.)



GENERAL ARRANGEMENT of the blowing type boundary layer control system in the Lockheed STOL transport is shown in the drawings above. High pressure air is supplied by special engines and ducted to the wing flaps and all control surfaces.

been marginal at low forward speeds on large BLC aircraft in the past, but Lockheed has used BLC on the tail control surfaces as well as the wing to avoid this problem on the modified C-130B.

Flight Tests

These characteristics with the boundary layer control C-130B have been verified by flight tests at Marietta, Ga., and Palmdale, Calif., by the Lockheed Georgia Division which designed, built and is testing the aircraft. First flight was made at Marietta on Feb. 8, and 15 hr. of high altitude testing was accomplished in 13 flights. The flights demonstrated control effectiveness, stall characteristics, effect of cutting one engine in the BLC system and cutting one of the propulsive powerplants while allowing plenty of room for recovery if any unusual flight conditions developed.

These flights showed that low altitude testing could safely begin, and the aircraft was sent to Palmdale to establish minimum take-off and landing performance on the very long runways there with long unobstructed runover areas.

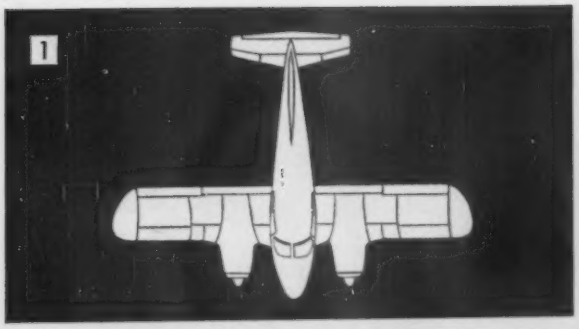
Typical Lockheed test results show that at 105,000 lb. gross weight the BLC C-130B will land well at 70 mph., compared with 105 mph. for the unmodified transport. Landing rolls for the two aircraft are about 450 and 1,800 ft. respectively. Stall speed for the BLC aircraft at this weight is just above 50 mph., compared wtih about 85 mph. for the unmodified C-130B.

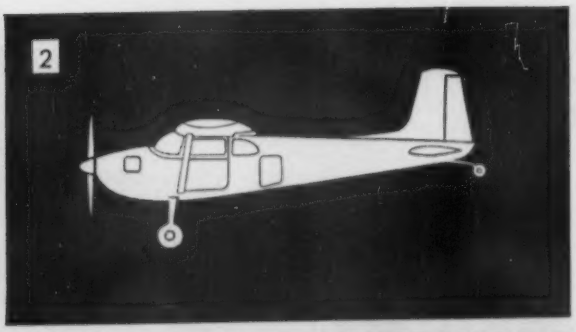
Development of the BLC C-130B began late in 1958 after more than two years of study proposals to the Air Force to meet General Operating Requirement 130, which called for a transport which would carry a 20,000 lb. payload 1,000 naut. mi. and make a midpoint landing and takeoff on an unprepared field 500 ft. long.

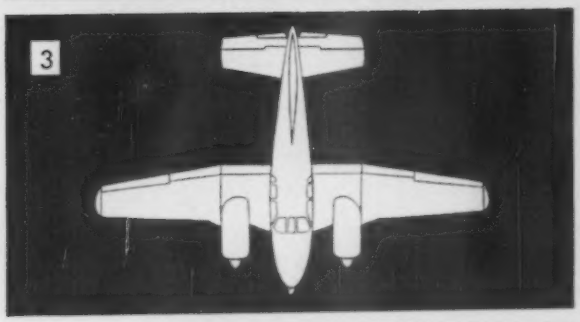
Air Force supported the development of the BLC C-130B for about a year with an expenditure of more than $5 million before the project was dropped late last year, primarily because of limited research and development funds. At that time, the modified C-130B was nearly ready for its first flight. Lockheed decided, with Air Force approval, to continue the project through flight test with its own funds. Flight test results are expected to increase the sales attractiveness of the aircraft to USAF, as well as to foreign air forces. Total amount of Lockheed's investment in the program is undisclosed.

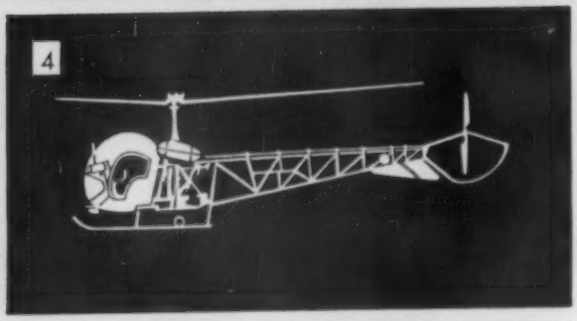
Wind Tunnel Tests

Design work was aided by more than 400 hr. of wind tunnel testing with a model of the C-130B equipped with a miniature BLC system, plus the large amount of flight experience and wind tunnel work from the original C-130B program. These wind tunnel tests were









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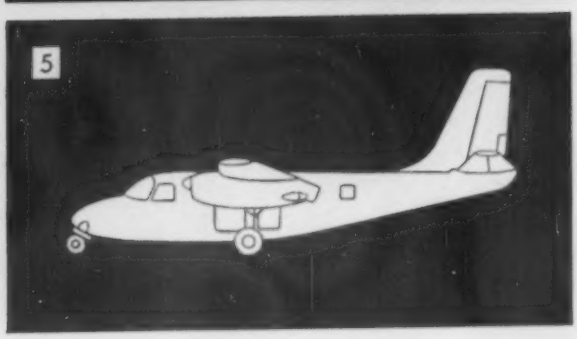

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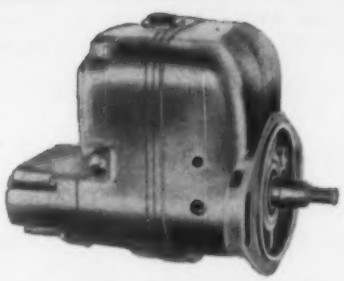

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TUNNEL MODEL of STOL C-130B was tested for more than 400 hr. Model has a complete BLC system; scale effects were not a serious problem in getting reliable data.

conducted in the United Aircraft Corp. 18 ft. wind tunnel at East Hartford, Conn.

Major changes made in the C-130B to produce the STOL version were to increase the rudder chord 40% and to add a duct and nozzle system in the wings and tail so that high speed air could be blown over the flaps, ailerons, rudder and elevator. High pressure air for this system on the experimental aircraft is supplied by two Allison YT-56-A-6 turbine engines located in pods, one under each wing. On production aircraft, Lockheed plans to have four smaller Continental 356-17 engines powering the BLC system.

One of the main design objectives was to make certain that there would be a minimum loss of lift in case of partial power failure in the boundary layer control system at any normal landing approach speed from about 95 mph. down to the stall speed of about 50 mph. To accomplish this, the BLC engines were sized so that one of them could maintain supercirculation lifting conditions on the wings through this entire speed range.

Lift Generated

As long as supercirculation conditions are maintained on the wing, the lift generated does not vary a great deal regardless of the energy in the air being forced out of the nozzles. However, if the momentum coefficient of this nozzle discharge air, which is a measure of its energy, drops to the point that some flow separation begins to take place on the wing, then the lift generated changes significantly for each small change in momentum coefficient of the BLC system.

Effectiveness of the flap system on the BLC C-130B was increased by drooping both ailerons 30 deg. when the flaps pass 40 deg. deflection. The mechanism which controls this movement also changes the gearing in the aileron control system so that their deflection rate is doubled after they are drooped.

Nozzle System

Wind tunnel tests of the BLC model indicated that the forward part of the horizontal tail might have to be deflected upward or that a blowing nozzle and duct system might have to be added to the lower part of the horizontal tail leading edge.

Flight tests did not indicate that these changes were necessary, although wind tunnel data had shown that when the boundary layer control system was on at high angles of attack, a flow separation occurred on the lower part of the horizontal stabilizer, reducing its effectiveness.

At these high lift coefficients, the flow downwash angle off of the wing is very large and the horizontal tail is operating at a large negative angle of attack, with the flow approaching it from above. Scale effects between the wind tunnel model and the full size aircraft are believed to account for the prediction that the horizontal tail would stall when it actually did not.

Addition of the pods for the BLC engines cut about 10 kt. from the average cruise speed of the C-130B on a typical mission.

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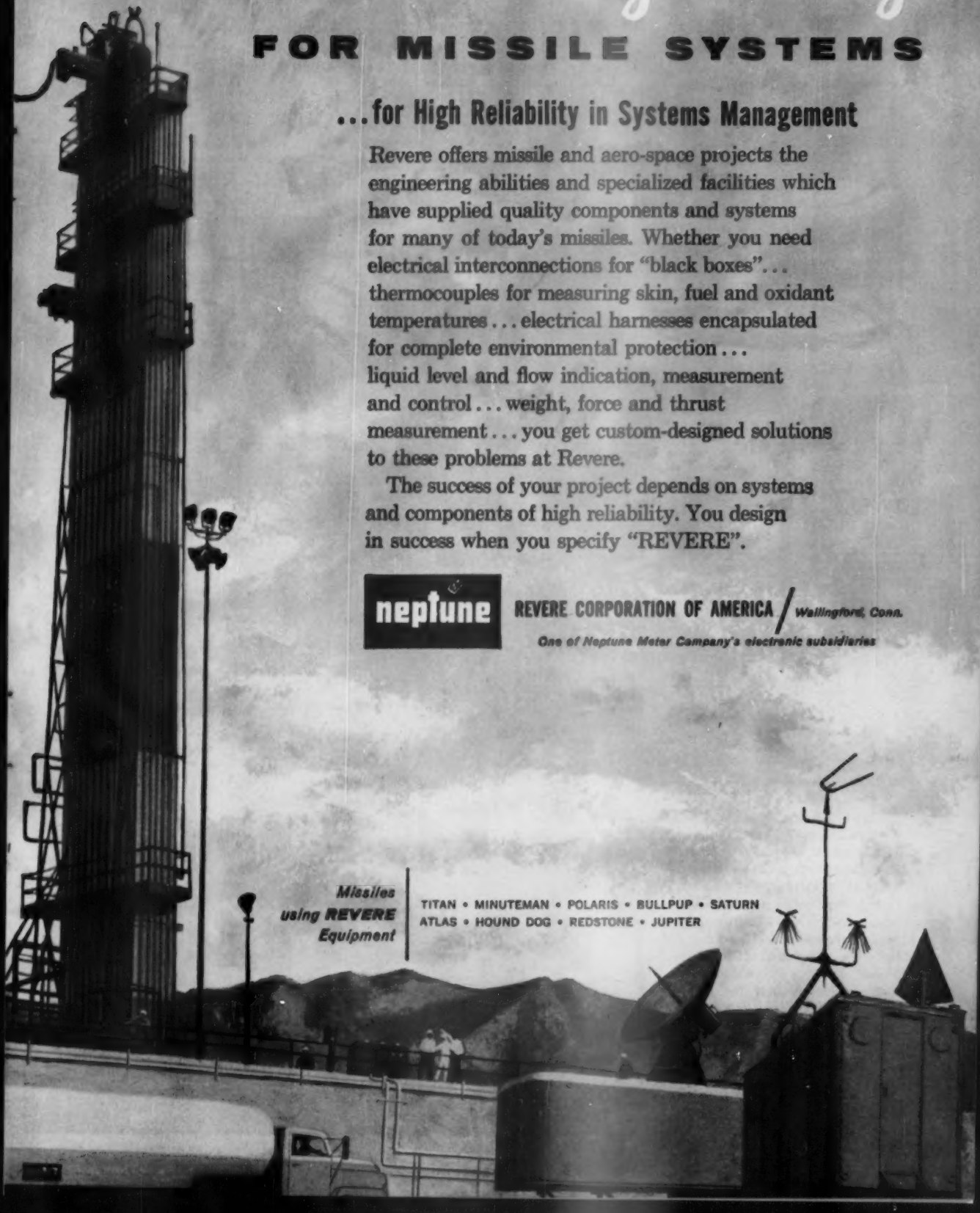

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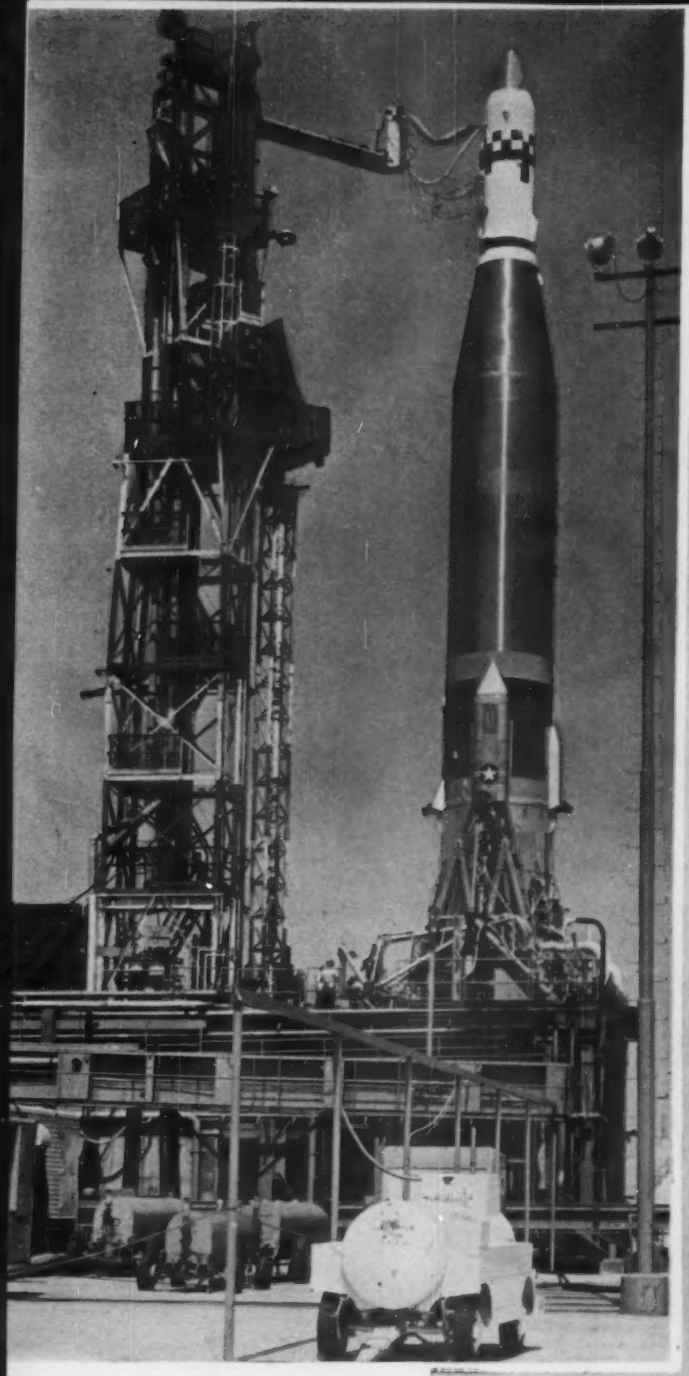
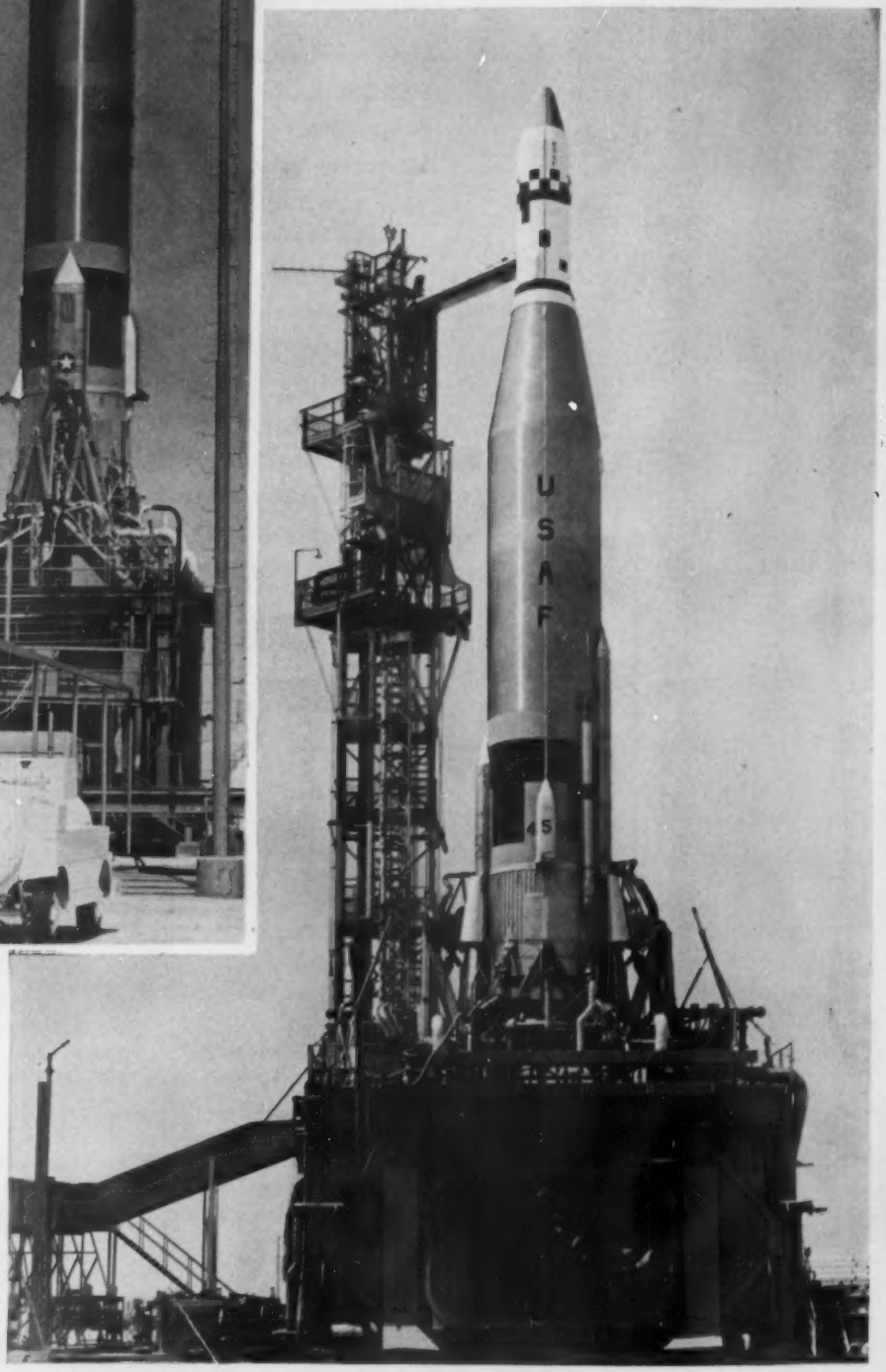
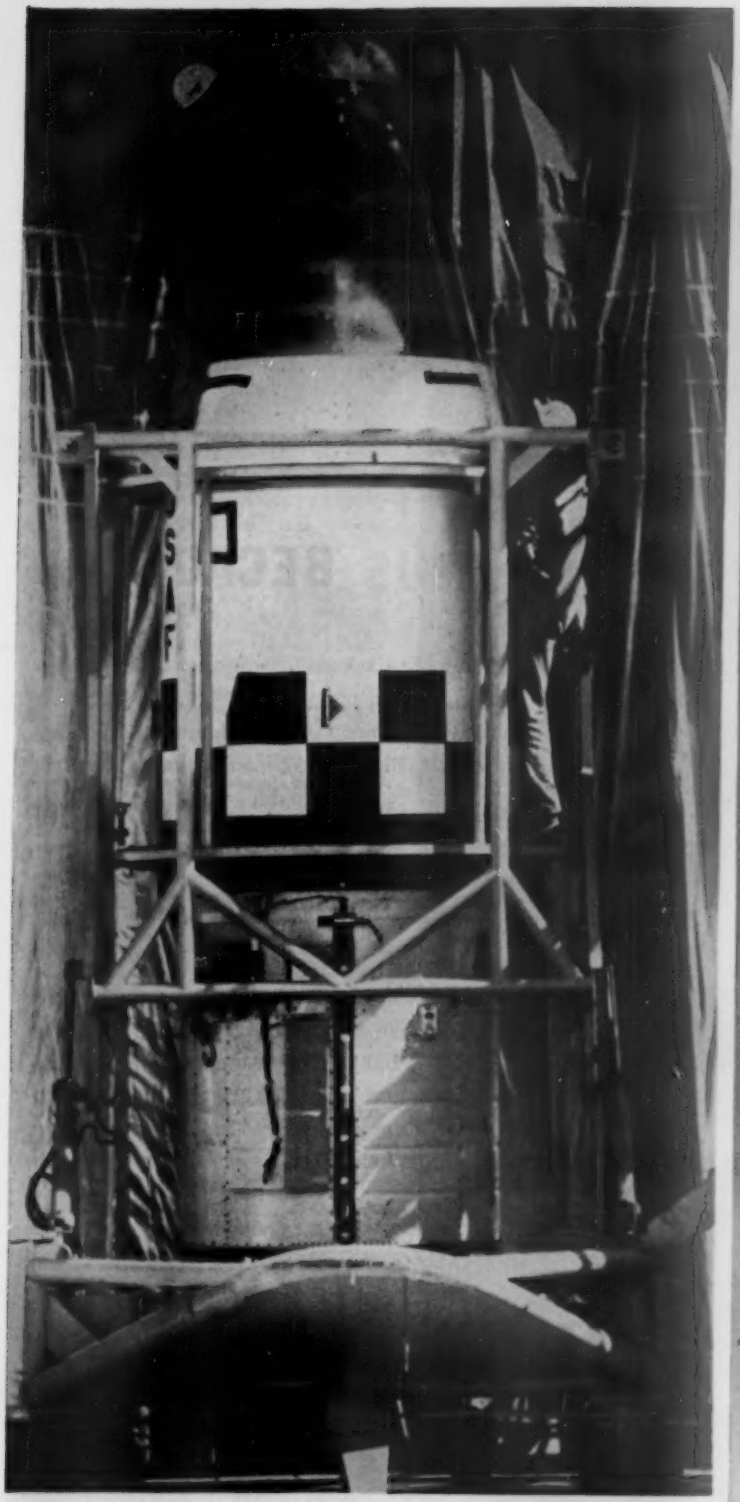
Second Launch Succeeds, Puts Midas Into Orbit

Second attempt to launch USAF-Lockheed Midas from Cape Canaveral, Fla., was successful but telemetry failed after 16th orbit, cutting short infrared measurements and monitoring of later launches.

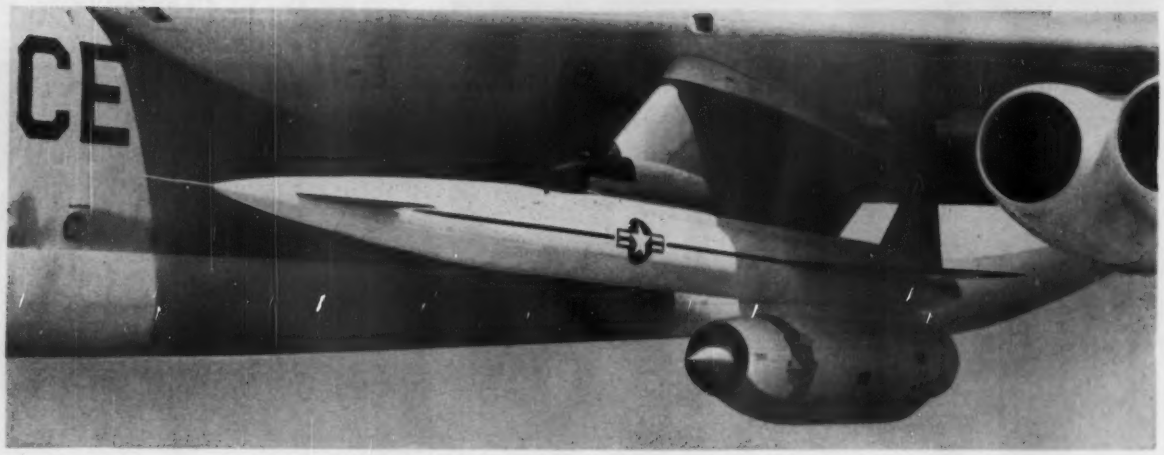




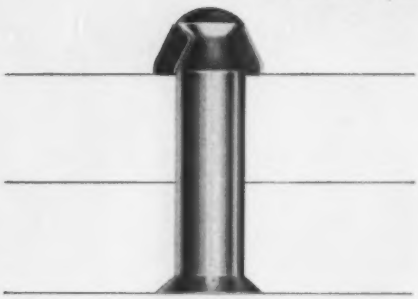
Midas launch complex at Air Force Missile Test Center is a modified USAF-Convair Atlas facility. New launch complex for Midas and Samos electronic-optical reconnaissance satellite has been completed at Naval Missile Facility, Pt. Arguello, Calif., where most of the research and development program for both will be carried out. Both systems call for polar orbits so operational firings also will be made over Pacific Missile Range. Midas stage, shown mounted on Atlas 45-D, stands 21 ft. 8 in. high, weighs 5,000 lb.



Entire upper stage (above) goes into orbit, is oriented nose-down toward earth with an infrared scanner operating through a window. Filters adjust sensitivity of the sensor, which checks radiation recorded against background radiation. Right, Midas II is launched successfully into a near-circular orbit (AW May 30, p. 36), becoming heaviest U. S. satellite to date.

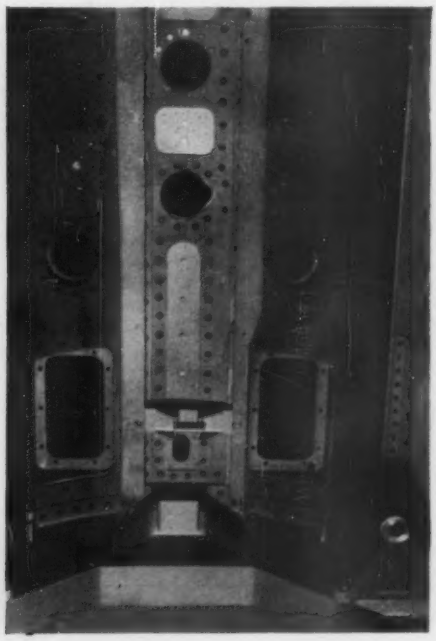


PERFORMANCE PLUS BECAUSE...



Stainless Steel Hi-Shear rivets, used throughout the Hound Dog in shear applications, meet 125,000 psi minimum shear and 220,000 psi tensile range requirements. Combined with R-Monel collars, these Hi-Shears can be used to temperatures up to 800°F.

Hi-Shears fasten structural fittings in the Guidance Compartment Doors (right) and primary structure in the Auto-Navigator area (below).



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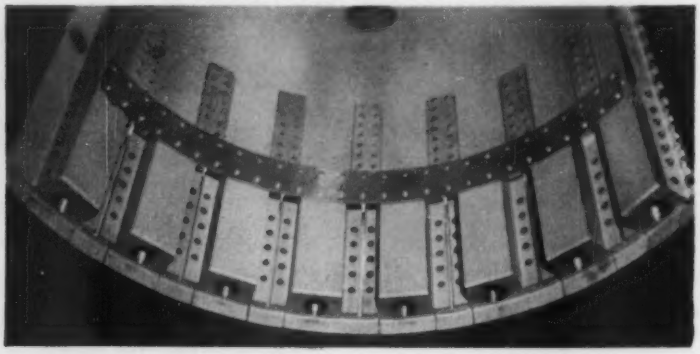

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ARPA Spurs Space Power Investigation

Pasadena, Calif.—Aerospace industry investment in design and development of secondary power systems for space vehicles has jumped from millions to hundreds of millions of dollars in the last two years. To give guidance to the industry, Advanced Research Projects Agency is issuing a 2,000-page handbook dealing with techniques for generating from 10 watts to 20 megawatts at constant load for space vehicle applications.

The handbook, scheduled for September delivery, emphasizes solar-thermal and nuclear energy sources (AW Apr. 4, pp. 26-28) but also considers selection criteria applicable to remote earthbound electrical power generation systems.

"Handbook for Power Systems" is being compiled by Electro-Optical Systems, Inc., for ARPA under a $93,000 contract administered by USAF Wright Air Development Division. The word "space" originally was included in the title but was deleted when ARPA was taken out of the space business (AW Sept. 28, p. 27).

In attempting to lay out guidelines for secondary power source development, the Electro-Optical study team has sought a single quantitative index by which all types of secondary power systems can be evaluated for specific missions.

Walter R. Menetrey, head of the handbook program, told AVIATION WEEK that the effort to find a single index or optimization formula had been balked, so far, by the qualitative factors imposed by many missions. Instead, the handbook will list qualitative limiting factors and show how to use the individual figures of merit for weight, cost and reliability. Some qualitative considerations are growth potential, component availability, means of integration with the vehicle, and adaptability of the power supply to instrumentation and other equipment on board.

SOLAR test facility at Electro-Optical Systems, Inc., is used for studies of energy conversion characteristics, as well as heat rejection capabilities of various materials.

Electrostatic Generator

Space exploration has revived interest in the electrostatic generator, an ancient device superseded nearly a century ago by electromagnetic generators and used only in the laboratory since then. It seems especially promising for systems using ion or colloidal rockets for orientation or propulsion. Specific impulse of ion or colloidal motors is proportional to direct current voltage. Electrostatic generators begin to show an advantage over electromagnetic at very high voltages.

According to theory, 50 kv. is the cross-over point at which electrostatic generators become lighter than electromagnetic generators. This 50 kv. value also is the potential needed for ion propulsion. Optimum voltage for electrostatic generators probably is more than 100 kv. This level is not needed for presently projected ion motors but may be needed for colloidal propulsion, Electro-Optical investigators say.

Electrostatic Generators

Electrostatic generators should be able to match the five-pound per kilowatt specific weight of d.c. electromagnetic generators but probably will not achieve the one-pound per kilowatt of good aircraft-quality alternators. They have several practical advantages over electromagnetic generators for space work.

Rotor of the electrostatic generator is all-metal with no insulation required, and therefore higher temperatures can be tolerated. Variable capacitance electrostatic generators, which now appear most promising, have no pressurization problems in space. Vacuum provides the best practical dielectric and this can be obtained in space merely by venting the generator case. The problem of brushes is simpler than with electromagnetic generators because the charge on rotor segments is always positive. It is satisfactory to use brushes which make contact on shaft bushings. A bushing usually is not a good contact because of the presence of lubricants, chips or other foreign substances. This is no disadvantage for an electrostatic generator because of the negligible current carried by the brushes. In fact, a bad contact helps to keep the positive charge from draining off the rotor. If a very good contact was used, a resistor probably would be inserted in the circuit for this purpose. Electro-Optical investigators are certain they can achieve 95% efficiency with the variable capacitance

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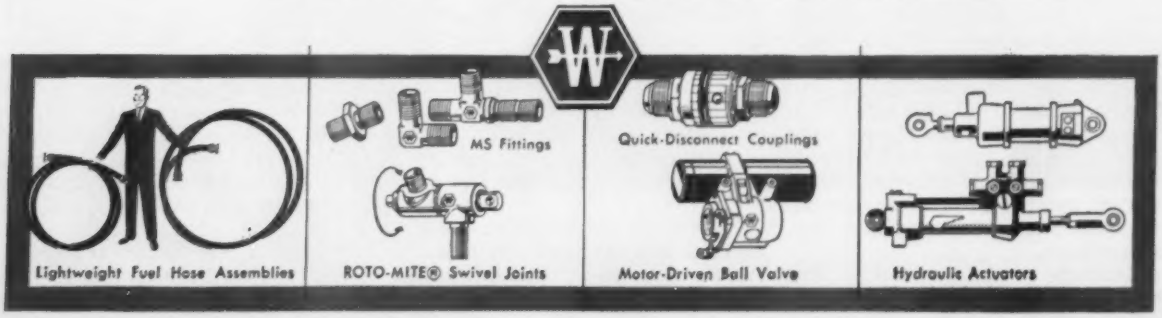

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electrostatic generator. French and German groups already have reached 90% using gas dielectrics pressurized to 20 atmospheres. A vacuum would provide equally good dielectric strength but without sealing problems and aerodynamic drag losses.

Problems to be solved for the electrostatic generator are:

- **Isolation from lubricants** and turbine working-fluids to prevent their entering the generator case and breaking down the dielectric gap.
- **They require nearly constant load.**
- **Stronger, more rigid materials** are needed to maximize rotor speed and segment width, while minimizing its thickness. Rotor size and weight can be reduced as speed increases, so speeds should be as fast as materials will allow. Present indications are that they will be operating at the same speeds as modern lightweight electromagnetic generators, about 50,000 rpm. Ion propulsion will require megawatts of power. High voltages needed for top specific impulse would have to be stepped down for lesser needs.

Rotor Segments

Rotor of the electrostatic generator looks like a fan with the blades flattened. It spins within a segmented stator. Rotor and stator segments are, in effect, the opposite plates of a capacitor. Alternate stator segments are linked by circuitry which includes the load and a simple rectifier. As a positively-charged rotor segment passes a stator segment it draws a negative charge onto that segment and through the load circuitry places a positive charge upon the adjacent stator segment which is not opposed by a rotor blade. As the moving rotor blade approaches the adjacent stator segment, stator charges and the polarity in the unrectified circuitry are reversed.

To convert solar energy directly to electricity, thermoelectric generators would probably be most effective if located within a heat absorber at the focal point of a solar concentrator. Probably the absorber would be in the form of a hollow vessel or cavity with a single small orifice pointing into the concentrator and located at its focal point. The interior surface of the cavity would be highly absorptive and would serve as the cathode of a large thermionic diode or would be lined with thermocouples. If a solar turboelectric system is chosen, boiler tubes carrying the turbine working fluid could be embedded in the cavity walls. The efficiency of absorption for a cavity should approach that of a black body. Less than 10% should be reradiated through the orifice and lack of an atmosphere would prevent losses due to conduction and convection.

A critical problem tackled by the Electro-Optical study is that of energy storage. Where nuclear power is used or the mission does not involve a low energy orbit partially in the shadow of a plane, storage is unnecessary. With present nickel cadmium batteries about two watt-hours can be stored per pound of battery.

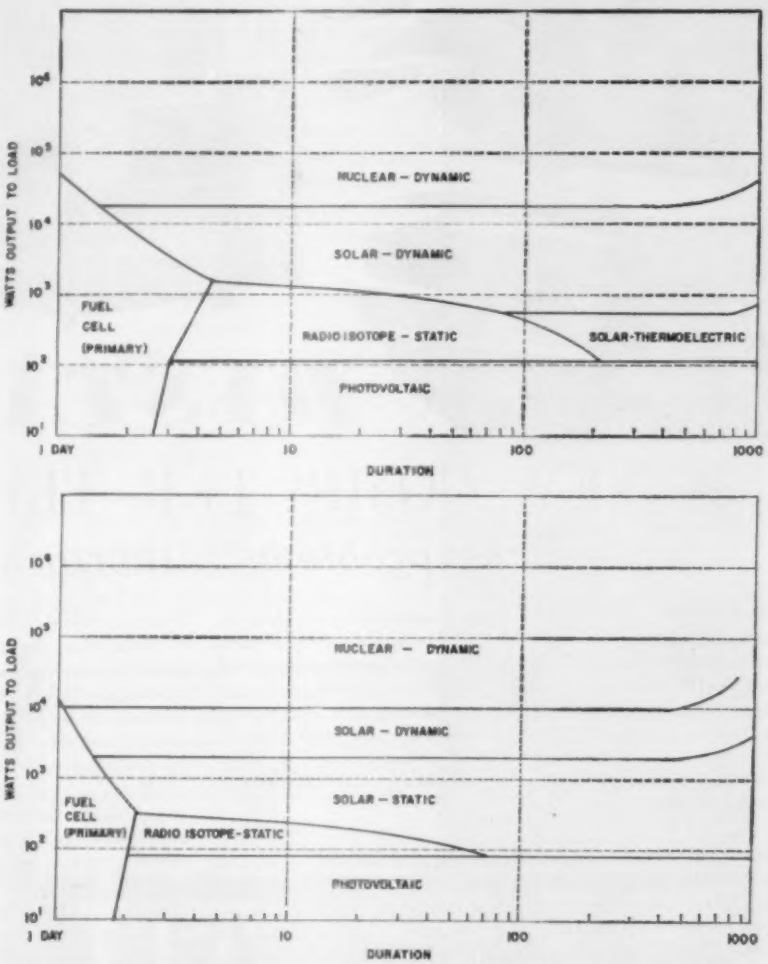
Cryogenic Storage

Silver cadmium batteries may approach four watt-hours per pound and present fuel cells in development are capable of storing 20 watt-hours per pound. With cryogenic storage of the regenerated fuel, it may be possible to achieve 800 watt hours-per pound. Receiving increasing attention from investigators is thermal storage. It seems possible to store as much as 100 watt-hours per pound and with extremely high efficiency. Heat could be stored by lining a cavity type absorber with a material such as lithium hydride which can absorb 1,600 Btu. per pound. The liner might be heated to a molten state during the light portion of an orbit and then continue to release heat for conversion to electricity during the dark part of the orbit, while returning to the solid state. Efficiency should be on the order of 90%.

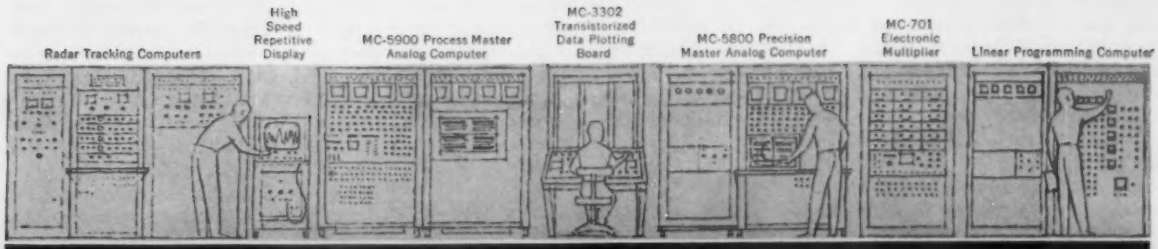
The Electro-Optical analysis indicates that power levels over 10 kw. will almost invariably require nuclear systems. The exceptions will be units for those missions in which nuclear radiation is intolerable and those requiring exceptionally long life.

Large Reflectors

In the region between 1 and 10 kw., high-temperature solar systems using concentrated energy from large paraboloid reflectors will eventually have the edge. The advantage may not be realized for some time because of present inability to design optically accurate solar concentrators which are large enough and yet packageable in small volume to meet the requirements of space missions. Mirrors 40 ft. in diam-



CURVES compiled by Electro-Optical Systems, Inc., scientists indicate their estimates of which types of secondary power systems will meet various power output requirements over various mission durations for minimum weight in 1965 and 1970.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eter will be needed for 10 kw. systems. They probably will not be available before 1970.

Low energy orbits around the moon, earth or other planets will introduce the problem of energy storage to supply power in the dark half of the orbit. Chemical batteries are the only means now available for doing this. They are much too heavy for the output levels which will be needed in ambitious space programs of the future. Better energy storage schemes being developed include fuel cells as well as thermal storage.

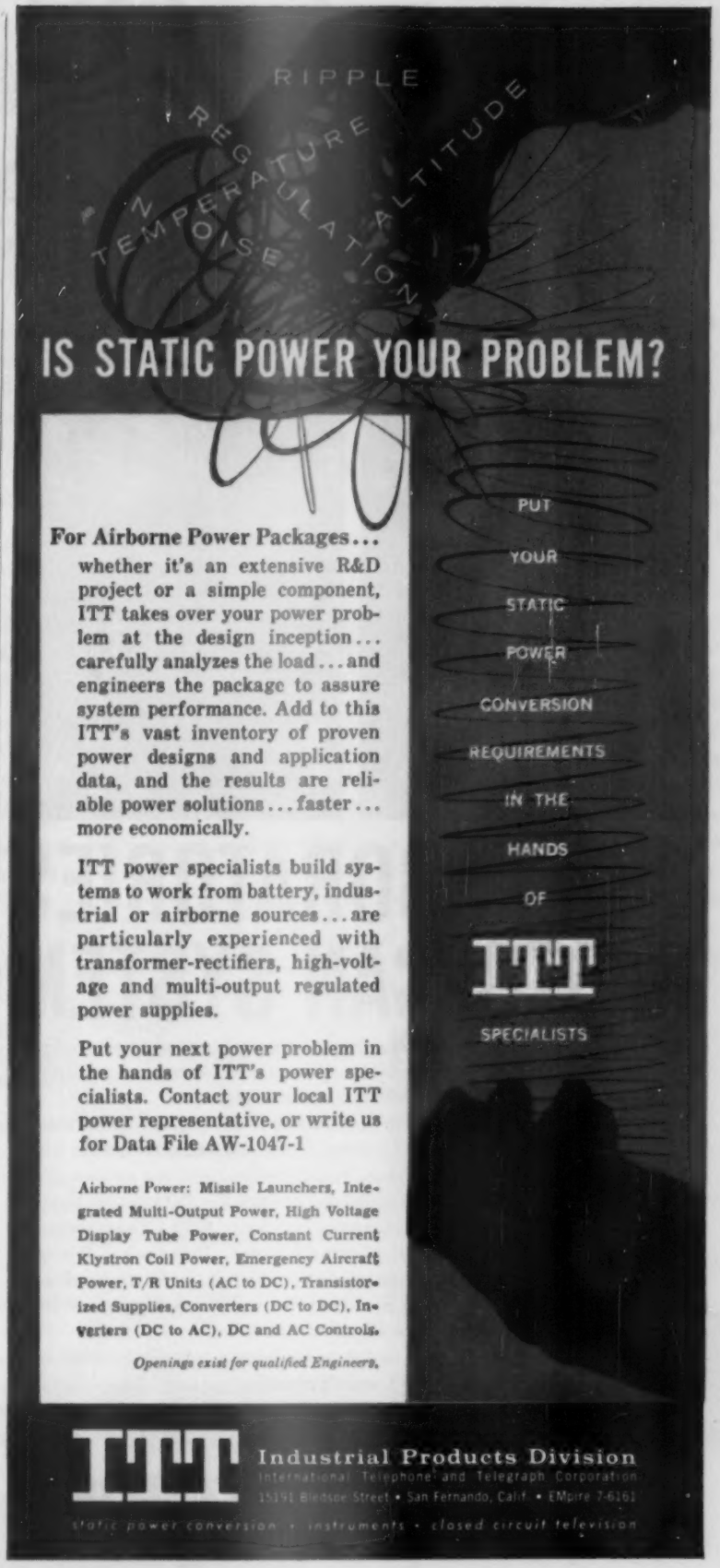
If fuel cells are used to generate secondary power, solar energy might be employed to regenerate the used fuel. Satisfactory thermal storage may be as much as four years away, so cost is hard to define. In the same time solar regenerative fuel cells may achieve an efficiency of 20%. Thermal dissociation is the most promising regeneration mechanism.

Heat Engines

The various dynamic and static heat engines which can be used to generate electric power face peculiar problems in space. All require a temperature difference between the input and output sides of the converter to function, since a flow of energy from hot to cold is necessary for conversion to a new form of energy. The energy potential is directly proportional to this difference. Therefore, it is desirable to raise the temperature of the hot side and lower the temperature of the cold side as much as possible to get the maximum Carnot efficiency and minimum system weight. This means that the continued influx of heat from the sun or from a nuclear power source on board must be balanced continuously by an equal dissipation of heat on the cold side.

Radiation is the only way in which heat can be dissipated in the vacuum of space. A radiator should operate at the highest possible temperature since its effectiveness varies with the fourth power of its temperature and weight is inversely proportional to effectiveness. There lies the design dilemma, for a reduction of radiator weight must increase weight of the rest of the system because of lower Carnot efficiency.

The temperature drop through the system can also be increased by raising the temperature of the energy source. However, materials problems limit the top temperature at which a nuclear fission reactor can function and the advantage to be gained in a solar system diminishes as the weight of the solar concentrator begins to exceed that of the radiator. In general, radiator weight dominates the design of a large nuclear secondary power system and concentrator weight dominates the design of solar-thermal systems. Shield weight is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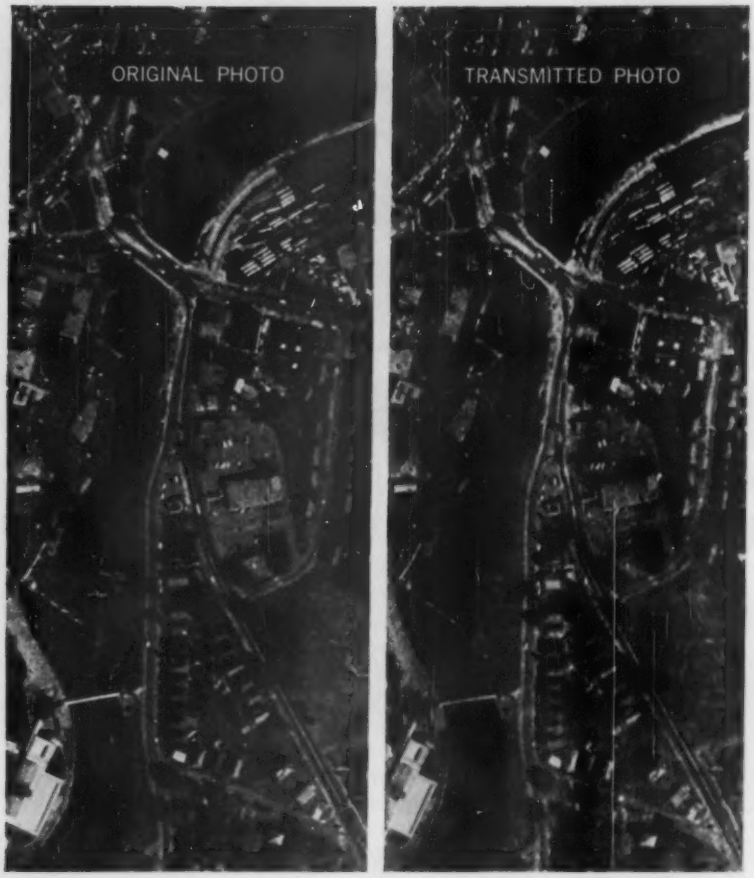

CBS LABORATORIES PHOTOSCAN SYSTEM

PHOTOSCAN, a radical advance in aerial reconnaissance technique, makes it possible to transmit visual information from manned or unmanned aircraft to ground receivers in seconds, without loss of detail.

The high performance of CBS LABORATORIES PHOTOSCAN is illustrated above. On the left is an enlarged portion of the original aerial photo which covered an area of sixty-four square miles. On the right is a portion of the reconstituted picture after transmission through the PHOTOSCAN System.

Challenging career opportunities are available at CBS LABORATORIES on long-range systems development programs such as PHOTOSCAN. Positions for physicists and electrical engineers are now open in the following department: Military and Industrial Systems; Acoustics and Magnetics; Solid State Physics; and Vacuum Tube Physics.

Please forward resumes in complete confidence, or obtain additional information by contacting CBS LABORATORIES.

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the dominant factor in low-power reactors. Maximum heat source temperatures attained with reactors in the SNAP programs (AW Mar. 28, p 31) are around 1,300F. Above that temperature, they begin to have trouble with hydrogen leakage from the hydride fuel-moderator elements which appear to be the best currently available. Dissociation and leakage causes the moderator qualities to change and causes cracking of the element. There is also some trouble with corrosion by the working fluid at high temperatures. In the distant future, uranium carbide fuel moderator elements should be able to make possible higher operating temperatures.

Solar concentrators at the earth's distance from the sun can produce temperatures up to 2,800F if materials can be found which will maintain satisfactory physical properties at that temperature. For missions closer to the sun, a given temperature and power level will be available with a smaller concentrator because of the higher solar energy constant there. At the earth's distance from the sun, solar constant is about 130 w. psf. The figure is higher near the inner planets Mercury and Venus because the solar constant varies inversely with the square of distance from the sun.

It is now possible to build static or dynamic heat engine powerplants with specific weights under 10 lb. per kilowatt for power levels over 200 kw. Nuclear reactor heat sources operating at 1,700F to 2,000F with exotic working fluids such as potassium, rubidium and sulphur should bring this down to about six or seven pounds per kilowatt within 10 years. Comparable advances in radiator design may lower radiator weight from current estimates of between 1-2 psf. to ¼ or ½ psf.

Reactor Systems

By 1970, nuclear reactor-driven secondary power systems are expected to predominate for all missions requiring much more than 10 kw. output for periods much over one day. For mission durations measured in hours, non-regenerative fuel cells may be able to provide these power levels. Solar concentrator-absorbers with turbo-generators should win most of the jobs between 3 kw. and 10 kw. for mission durations over two days. With static conversion rather than rotating machinery, solar concentrator-absorbers are likely to be used between 100 w. and 3 kw. Below this band photovoltaic cells should continue to hold their own for long duration missions (AW June 13, p. 79).

Radioisotope energy sources will find some utilization at power levels of a few hundred watts for durations up to 70 days. Unfortunately, isotopes which have a high energy output per pound also have very short half lives. For high

TIROS I...

"mission accomplished"

By the end of its first week in orbit, TIROS I had already accomplished its basic mission as an exploratory vehicle. It had established beyond doubt that meaningful cloud-cover pictures could be obtained by a satellite, and that the complete system set up to acquire them worked.

The payload performance more than lived up to expectations, sending down thousands of valuable cloud cover pictures for study and giving man his first consistent "star's eye" view of his own planet.

TIROS was placed in an almost perfectly circular orbit. This was due to the fine engineering talents of the Douglas Aircraft Company which, in cooperation with the Aerojet-General Corporation, Bell Telephone Laboratories, and Alleghany Ballistics Laboratory, built the Thor-Able launching vehicle for the U. S. Air Force.

Developed and built by RCA Astro-Electronic Products Division under the auspices of the National Aeronautics and Space Administration and the technical direction of the U. S. Army Signal Corps, TIROS I is actually the work of many hands. Here are some of the important sub-contracted equipments which contributed to the successful functioning of TIROS.

The Beacon Transmitters broadcast a tracking signal and telemetered vehicle parameters. These transmitters and the telemetry switches were supplied by the ASCOP Division of Electro-Mechanical Research, Inc.

The Infra-Red Horizon Detector assists in the determination of the position of the satellite spin axis in space. The detector was made by Barnes Engineering Co.

The Clock and Sequencing Units which time and control the remote operation of the TV cameras were supplied by the General Time Corporation.

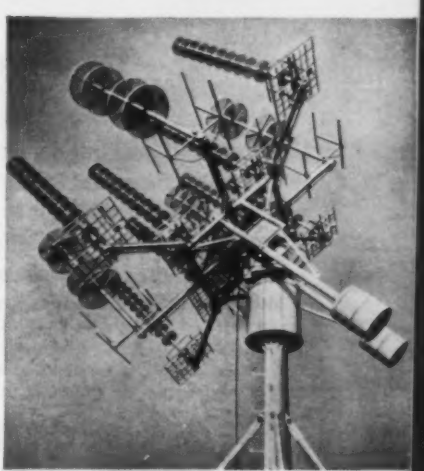
The TV Transmitters are 2-watt FM units which send down both the video signals and accompanying North-Indicator signals. The transmitters were manufactured by Radiation, Inc.

The Tape Recorders are the heart of the satellite's remote picture storage capability. The castings were produced and machined by Bridge Tool and Die Works, Inc. according to specification supplied by RCA.

The Power Supply of TIROS I consists of a solar-cell matrix (containing more than 9,000 cells) which is used to charge 63 Nickel-Cadmium storage batteries. The cells were made by International Rectifier Corporation. The batteries were supplied by Sonotone Corporation, and the DC to DC power converters by Sorenson and Company.

Spin-Up Rockets mounted around the base perimeter of TIROS I will be used, when necessary, to restore the satellite's spin rate to the optimum value of 12 rpm. They were made by the United States Flare Corporation and Associates.

This is by no means a complete inventory of the payload of TIROS I. Numerous other suppliers provided components and services for the satellite and the ground station equipment essential to the success of the mission. Other items were manufactured entirely at RCA's Astro-Electronic Products Division. And it was here that the complete system was designed and integrated into the highly successful satellite package and associated ground station equipment for the TIROS project under the technical direction of the U. S. Army Signal Research and Development Laboratory.



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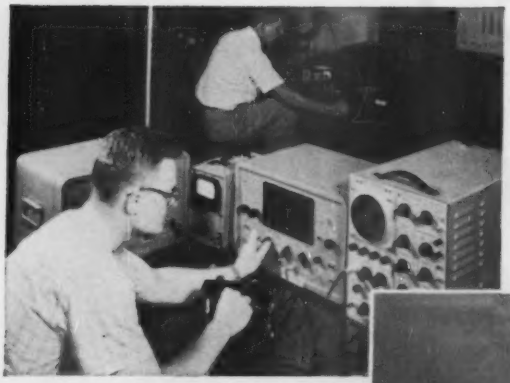

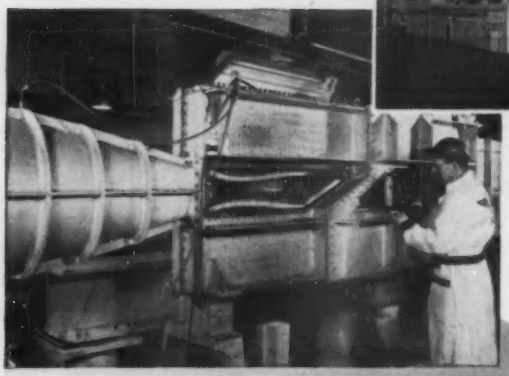

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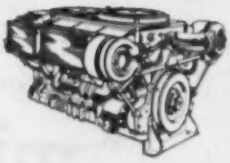

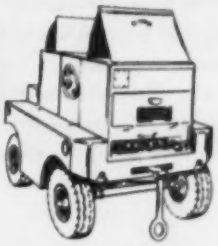

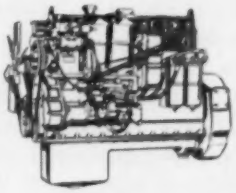

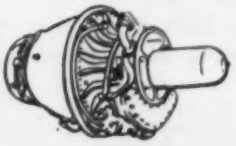

CAE is also equipped for a wide variety of subcontracting operations. Detailed information about its production facilities will be sent on request.

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power levels and long life, they become far too costly. There may not be enough radioisotope material in the entire country to drive a 50 kw. power supply.

In 1965 the distribution of missions will look a little bit different because of the early stage of development of solar systems. This will make isotope sources better for some missions requiring power levels of more than a kilowatt and durations up to 120 days. Photovoltaic cells will be used to produce over 100 watts.

Electro-Optical contemplates the use of the entire external skin of the space vehicle as radiator surface. This double use of the surface would provide ample area from which to dissipate heat at minimum cost in weight. Cabin and instrument compartment could be refrigerated to make possible radiator temperatures as high as the tradeoffs between radiator efficiency and total system efficiency dictate.

Efficiency of the energy converter selected is a vitally important parameter in holding weight of the secondary power system to a minimum. This is especially true with solar-thermal converters because the solar concentrator can account for nearly half of system weight. More efficient conversion means that for a given power output energy input can be smaller and solar concentrator can be lighter. Weight of the converter itself is about 20% of total system weight. Controversy continues as to whether turbine-driven generators or direct-conversion thermalelectric devices will be most reliable in space.

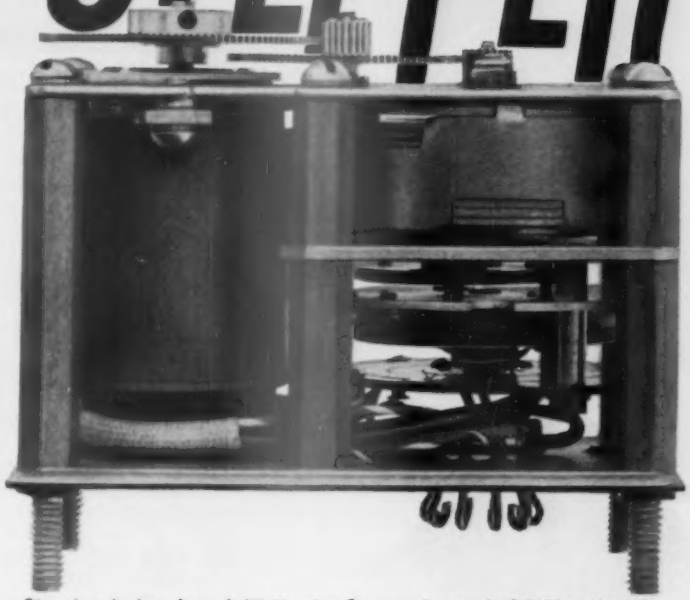
Rankine Cycle

Rankine cycle turbines are quite efficient. Present ones using mercury as a working fluid attain an efficiency of about 15%. Versions suitable for space are not operational yet and more exotic working fluids will probably be adopted. Under consideration as new working fluids are potassium, rubidium and sulphur. These maintain good physical properties at a wider range of temperatures than mercury, thereby permitting a higher Carnot efficiency.

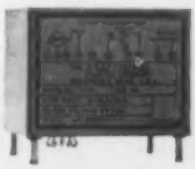
Non-dynamic converters of interest include: thermionic emitters, Seebeck generators or thermocouples, and photovoltaic cells. Less promising, at least for the immediate future, are photochemical conversion, radio dissociation by bombardment with charged particles, magnetohydrodynamic generators, pyroelectric conversions, nuclear fusion reactors and ferroelectric converters.

Thermocouples and thermionic emitters can be used with both nuclear and solar energy sources. Menetrey is predicting that by 1970, turbogenerators will be used for all power levels above a few kilowatts. Between this range and about 100 w. solar-thermoelectric conversion will find a role. In the more dis-

FANCY STEPPER



Stepping devices from A. W. Haydon Co. can do wonderful things to pulses ...with pulses...and for pulses. For instance, one precision gated stepping switch acts as a pulse divider for a random or variable pulse source—or as a frequency divider if the pulse source is constant. Another works in conjunction with pulses, supplying single or multiple switch closures with an accuracy virtually equal to that of the pulse source itself. Still a third will count a predetermined number of pulses, rotate a stepper switch, return the counter to 000, and cut off the pulse source. ■ The remote positioning device illustrated is but one of A. W. Haydon Company's fancy steppers. Here a precision gated stepper switch has been coupled to a synchro transformer. Similarly, precise angular positioning of rotary components such as potentiometers, dials and indicators can be controlled. Based only on the number of pulses received (not incremental changes in voltage or phase angle), it will hold a set position whether power is on or off, and will home the synchro to the zero reference on demand—ready to accept another setting. ■ All A. W. Haydon Co. stepper motors are all-electric—no ratchets, linkage, contacts or other mechanical crutches are used. Their power consumption is low, accuracy is extremely high. ■ Send for technical brochure SP9-1 and find out more about pulse driven steppers and their application.



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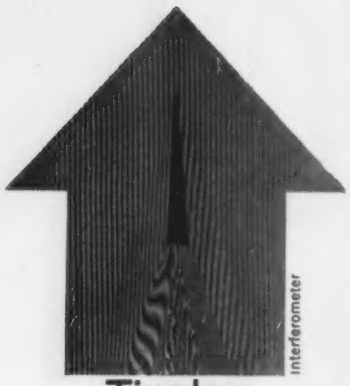

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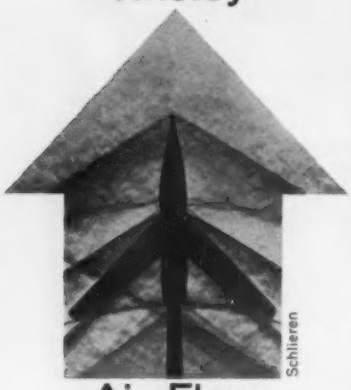

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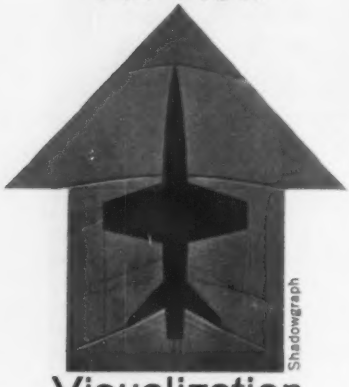

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Collins Builds Mercury Communications Mockup

Project Mercury capsule communications console mockup at Collins Radio Co. in Cedar Rapids, Iowa, is shown receiving a check-out by Project Mercury test pilot Malcolm S. Carpenter. Helmet which Carpenter is wearing contains dual microphones in the event one fails. Collins, under contract to provide 20 complete Mercury communication systems, already has delivered five systems to McDonnell Aircraft.

tant future, nuclear-thermoelectric conversion is likely to become competitive.

Thermocouple technology is progressing rapidly. Present ones are capable of an efficiency of seven per cent with a specific power of about three watts per pound of system. Most frequently used thermocouple material is lead telluride operating at from 600F to 1,150F. Within three years thermocouple efficiency is expected to rise to 15% with specific power as high as 12 w. per pound and operating temperatures ranging from 1,500F to 2,000F. One improvement which appears promising in the laboratory is the use of composite or stacked thermocouples in which several materials are used. The materials selected are chosen to produce maximum efficiency at different temperatures and stacked to match the temperature drop through the thermocouple. Position of each material in the stack is assigned to put it the correct distance from the heat source to give it the correct temperature for top efficiency. The efficiency of control and regulation devices for thermocouples can run as high as 80%.

Thermionic diodes now commercially available are capable of 4% efficiency. Prototypes now being tested are capable of 10% and efficiencies of 15% to 20% have been achieved in the laboratory. Theoretical limits are now set at between 35% and 40%. This level of efficiency should be approached in five or 10 years in the opinion of Electro-Optical scientists. Best operating temperatures should be around 2,500F. This is impossible at present because of inadequate heat sources and materials. Especially needed are new cathode materials offering longer life.

A nuclear thermionic diode reactor could be made by using the reactor fuel element cladding as a cathode and placing it within a tubular anode. Reactor cooling would pose a difficult problem with such an arrangement. One possible method would be to use hollow fuel-moderator elements as coolant lines.

Photovoltaic cells are the only type of solar conversion now available in an operationally suitable form. Efficiency is typically more than 10% without storage. With storage in nickel cadmium batteries to provide power during 35 min. of dark in a two-hour orbit, they have an efficiency of about 5%. Specific weight of the solar array and its controls is about 10 w. per pound. A single photovoltaic cell has a reliability of better than 99% over a one-year lifetime if the temperature range is held between minus 65F and 175F. At lower temperatures present photosensitive elements crack and at higher temperatures solder joints melt. Cost of a solar array is about $8 per square centimeter. Power output from the array costs about $530 per watt. When system inefficiencies are considered this figure rises to about $1,000 per watt. Like other solar energy converters, the photovoltaic cells' maximum output is set by the solar constant. A large portion of the solar radiation spectrum is unusable to a photovoltaic cell because photons in short wavelength radiation possess too much energy, resulting in heat losses.

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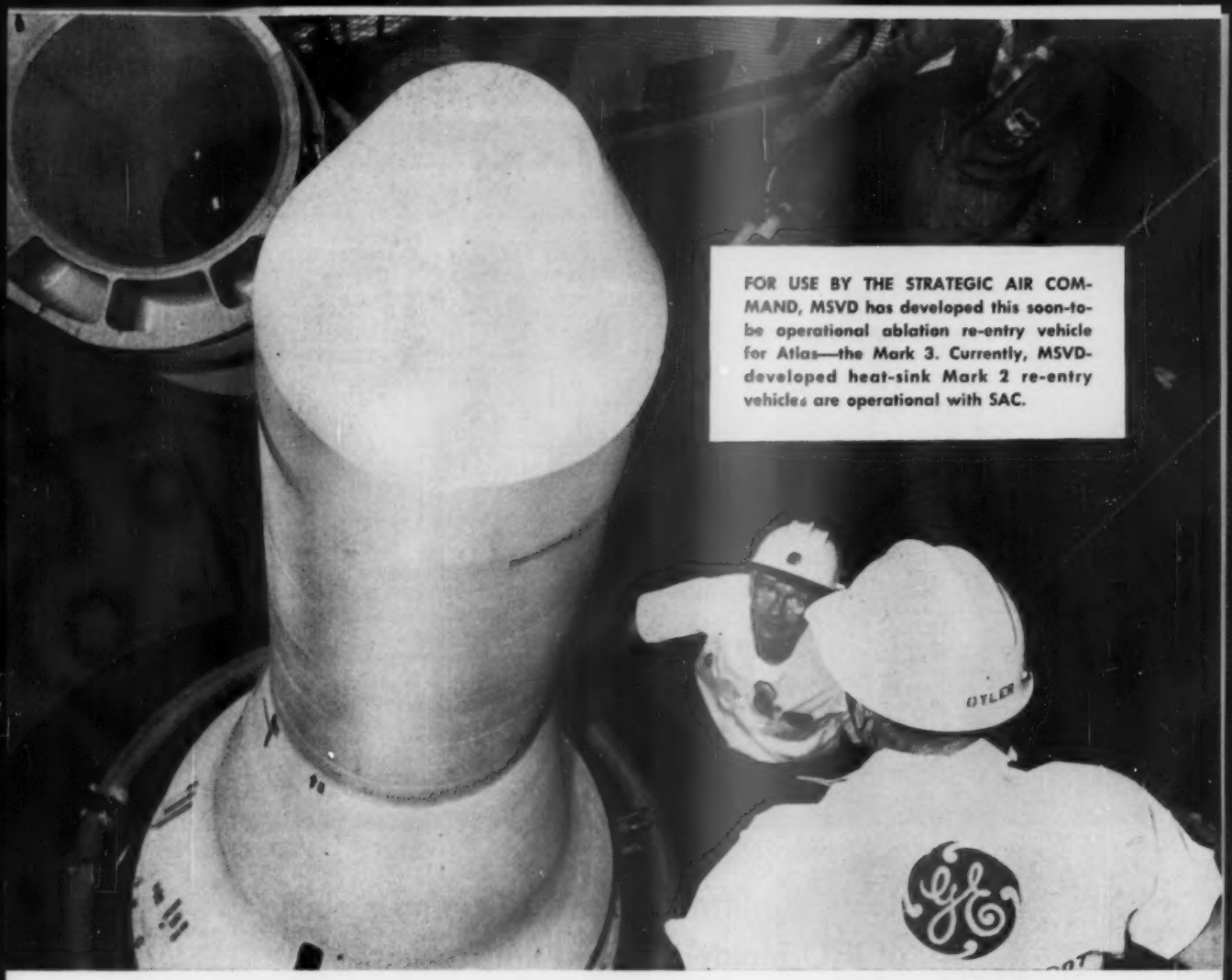

FOR USE BY THE STRATEGIC AIR COMMAND, MSVD has developed this soon-to-be operational ablation re-entry vehicle for Atlas—the Mark 3. Currently, MSVD-developed heat-sink Mark 2 re-entry vehicles are operational with SAC.

MISSILE AND SPACE VEHICLE DEPARTMENT

...center for missile and space technology research and development at General Electric

Progress in payload delivery for SAC

Today, as a vital part of SAC's deterrent weapon mix, Mark 2 operational re-entry vehicles developed by the General Electric Missile and Space Vehicle Department stand ready—helping to guard the peace of the Free World.

Continuing its progress under the direction of the Air Force Ballistic Missile Division, MSVD has developed an even more advanced re-entry vehicle—the Mark 3—which soon will be operational with SAC's missile squadrons. The Mark 3's payload delivery capability was dramatically demonstrated just 4 weeks ago when it successfully survived a 9,000 mile trajectory—longest re-entry vehicle flight in the world to date.

Now MSVD is designing and will build the re-entry vehicles for SAC's newest air-launched ballistic missile, the GAM-87A, SKYBOLT.

Hand-in-hand with this re-entry vehicle progress, MSVD has designed and developed items of re-entry vehicle ground support equipment for SAC. Latest of these is the air-suspension mating trailer, now being produced for SAC's use on both Titan and Atlas missiles.

Through such programs, MSVD continues to help increase the deterrent capability of SAC—strongest power for peace in the world today. Missile and Space Vehicle Department, General Electric Co., Philadelphia 1, Penna. 160-94

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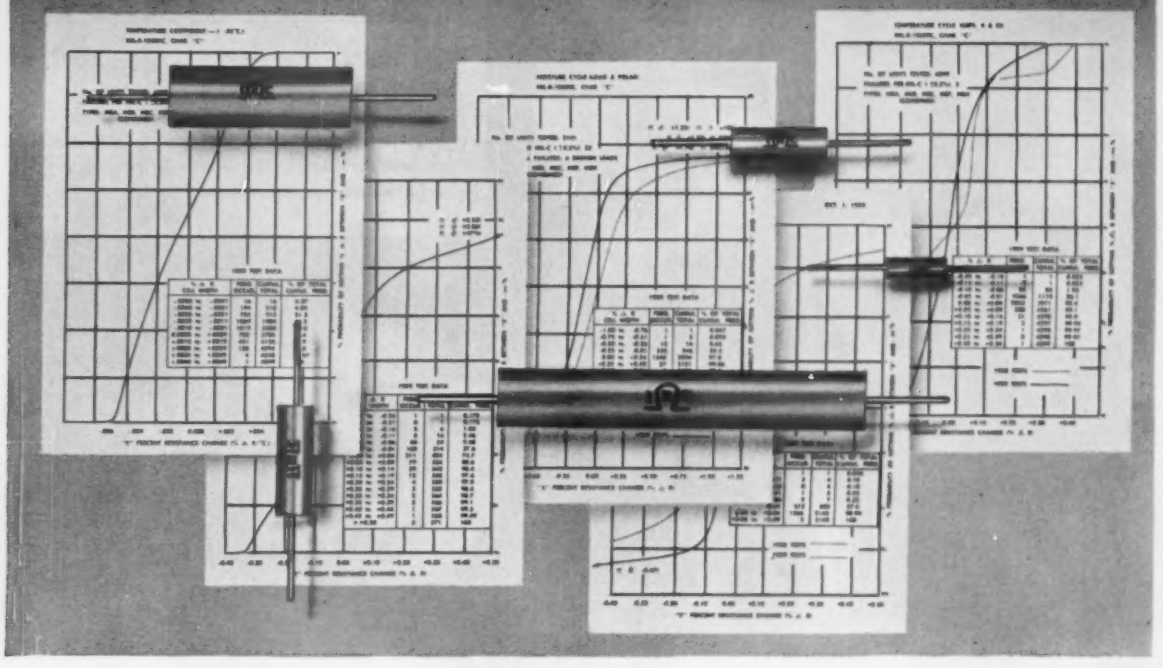
In PRECISION FILM RESISTORS : if it's news, expect it first from IRC



New tests confirm high reliability and stability of IRC Molded Metal Film Resistors

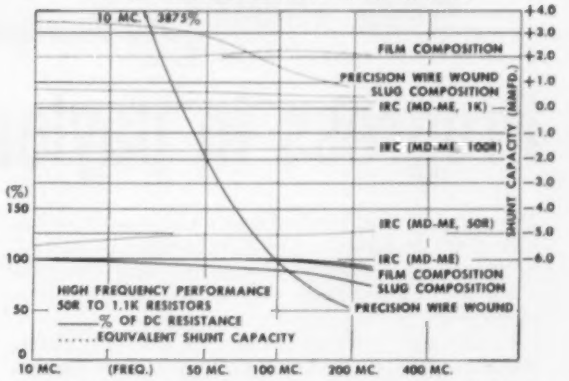
IRC has completed a new series of tests upon 7500 molded metal film resistors. The charted results are presented in a booklet just released: "Performance and Reliability of IRC Molded Metal Film Resistors."

This booklet is a sequel to IRC's report on a similar series of tests conducted in 1958. Where data are comparable, the earlier results are plotted against the new findings.

Tests are based upon MIL-R-10509C specifications, and are presented through the use of the probability technique. They include Temperature Cycle, Low Temperature Operation, Short Time Overload, Terminal Strength, Dielectric Strength, Effect of Soldering, Moisture Resistance, Temperature Coefficient and Load Life. Noise characteristics, shelf and operational stability, and high frequency characteristics are also reported and graphed.

The tests encompass IRC's full line of Molded Metal Film Resistors—5 types: ⅛, ¼, ½, 1 and 2 watts. The overall superiority of these advanced precision film resistors is shown conclusively. Their capability to provide high reliability over extended periods is confirmed again by this rigorous series of tests.

TYPICAL HIGH FREQUENCY PERFORMANCE OF IRC MOLDED METAL FILM RESISTORS



A booklet is reserved for your company and available by request on your company letterhead or through your local IRC representative. For product data, write for Bulletin B-3. International Resistance Co., Dept. 203, 401 N. Broad St., Philadelphia 8, Pa.

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First Ranger Shots to Test Components

Los Angeles, Calif.—First flight vehicles in the Project Ranger program, which are due to be launched next year, will aim at establishing longevity and reliability of systems and components of basic spacecraft.

Ranger program, (AW April 25, p. 26) projected to impact a scientific payload on the moon, and parts of the first flight hardware and later lunar impact payload were described here by Clifford I. Cummings, spacecraft program director at National Aeronautics and Space Administration's Jet Propulsion Laboratory, which has responsibility for the Ranger program.

To accomplish its mission, Cummings said, the basic Ranger vehicle (termed "the bus"), must incorporate:

- **Propulsion and guidance** for midcourse and terminal maneuvers.
- **Continuous and controllable** three-axis stabilization.
- **Logic circuits to allow changes** in mission according to varying conditions encountered in flight, with pre-programed information stored aboard on which to base changes.
- **Adequate power supply.**
- **Communications** which use available power and bandwidth most efficiently.

These systems will be part of the basic Ranger spacecraft and will be thoroughly tested in early flights. In addition, these early vehicles will carry some scientific instrumentation, primarily electrostatic analyzers for solar corpuscular radiation studies.

First Ranger spacecraft will be about 12 ft. long, with a large part of the length used in a tower structure on which will be mounted one omnidirectional receiving antenna, plus various instrument packages – rubidium-vapor magnetometer, ionization chamber, the corpuscular analyzers and a lyman-alpha telescope which will look back at earth to examine the nature of hydrogen clouds surrounding the earth. Total vehicle weight will be 700-800 lb. Power supply will be 90 watts, obtained from 20 sq. ft. of solar panels, which will require constant proper orientation toward the sun.

Atlas-Agena B will launch these first vehicles, while Atlas-Centaur will boost the later, lunar spacecraft. The lunar Rangers will be made up of the basic "bus," plus the impacting payloads and other scientific instrumentation. The buses will include a propulsion system for midcourse corrections to insure the lunar impact.

As the spacecraft approaches the moon some 66 hr. after launch, it will orient itself so that a television camera will be able to take a series of pictures with improving resolution as the space craft nears the moon (AW April 25, p. 26). During this same initial approach, a gamma-ray spectrograph will gather data for preliminary analysis of the fundamental lunar elements.

RANGER model shows spherical retrorocket (bottom), crushable structure, payload.

The bus will approach the moon at about 6,500 mph., and the survival capsule (to be supplied by Aeronutronic, a division of Ford Motor Co.) will separate some 20 mi. above the lunar surface. The bus will fly on into the moon and crash.

The survival capsule assembly will weigh about 200 to 300 lb. at separation from the bus, with most of the weight contributed by the retrorocket, which will slow it to about 200 mph. at impact.

Scientific instrumentation payload will be 17 lb., the remainder will be a crushable structure which will absorb the landing impact sufficiently to allow the instrumentation and communications to function after landing.

Instrumentation will include an impact accelerometer to measure landing impact, thermometer to measure lunar surface temperatures, seismometer to measure moonquakes and meteor impacts, power supply, transmitter, and a radiating antenna.

The same basic Project Ranger spacecraft bus, launched with Atlas Centaur, will carry later payloads to Mars and Venus.

For the Venus voyage, aim will be to gather data on the planet's atmosphere, to try to penetrate that atmosphere and learn more about the planet itself. Instrumentation will include an ultraviolet spectrograph, light polarization detector, passive (temperature) radar, active radar, magnetometer, solar corpuscular radiation analyzer, cosmic ray detector, and an infrared scanner.

On the trip to Mars, much of the same instrumentation will be carried, except that equipment to obtain a detailed infrared mosaic picture of the Martian surface probably will be substituted for the active and passive radar. The picture will be broken up into a number of reasonably small square sections, with the infrared response of that square indicated, which should make it possible to determine something about any possible forms of plant life.

SPACE STATION
POLARIS FBM
PROJECT ARGUS

DISCOVERER SATELLITE

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ADVANCED PROJECTS AT LOCKHEED

POLARIS FBM – Now in its advanced development status, the Navy-Lockheed POLARIS Fleet Ballistic Missile is scheduled to be fully operational and aboard its specially designed submarines late this year. Full-scale test vehicles have been successfully flown on a regular schedule of firings for months with only two failures, a remarkable achievement in view of the totally different environmental problems involved in its underwater launch. With nearly three-quarters of the earth's surface being water, practically no target in the world is outside the POLARIS' range of over 1200 nautical miles. The Division is system manager for the POLARIS under the direction of the Special Projects Office of the Navy.

SATELLITE PROGRAMS – The Air Force-Lockheed AGENA satellite is a versatile space vehicle capable of numerous assignments. In its present DISCOVERER program configuration, it is 19 feet long, 5 feet in diameter with an orbital weight of approximately 1700 pounds. Payload of several hundred pounds includes telemetry, instrumentation, guidance and attitude control systems, reentry vehicle and recovery capsule. The AGENA has accomplished several significant space "firsts." It was first to be placed on the difficult polar orbit; first to be placed on a precise, predicted, and nearly circular orbit; first to change its attitude on orbit, with a turn of 180 degrees and a downward tilt of 60 degrees; first to eject a capsule; and first to prove advanced space systems such as ground-space communications, instrumentation, attitude and guidance and life-sustaining devices. The AGENA can be modified for a variety of space missions such as navigation; geophysical investigations; lunar probes; long-range communications; and space probes.

In addition to the DISCOVERER program, the Division is developing advanced AGENA satellites for the MIDAS program (Missile Defense Alarm System) and the SAMOS strategic warning system. Lockheed is system manager and prime contractor for these projects under the direction of the Air Force Ballistic Missile Division (ARDC).

SPACE STATION – An orbiting research facility to serve as an advanced base for space exploration, has been proposed in practical detail by Lockheed's research and development staff. The station would carry a 10-man crew. Prefabricated compartments for the rim of the wheel, the spokes, and the three hubs would be launched separately by ballistic missiles and assembled in space by means of the specially-designed, Lockheed Astrotug.

X-17, KINGFISHER, X-7 – The Air Force-Lockheed X-17 solid-propellant ballistic missile has pioneered many new techniques, and the valuable experience gained from this program facilitated development of other, inter-service projects, including the Navy POLARIS FBM. The Navy's Project Argus radiation explosion featured the X-17 as the vehicle. Developed for the Air Force, the Lockheed KINGFISHER is designed to simulate enemy attacks to test our nation's anti-bomber and anti-guided-missile defenses. The Air Force X-7 is a unique, recoverable ramjet-engine test vehicle designed to test new developments in advanced components for other missiles.

The successful completion of projects such as these requires a bold and imaginative approach to entirely new environments. Lockheed's programs reach far into the future. It is a rewarding future which scientists and engineers of outstanding talent and inquiring mind are invited to share. Write: Research and Development Staff, Dept. F-17B, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

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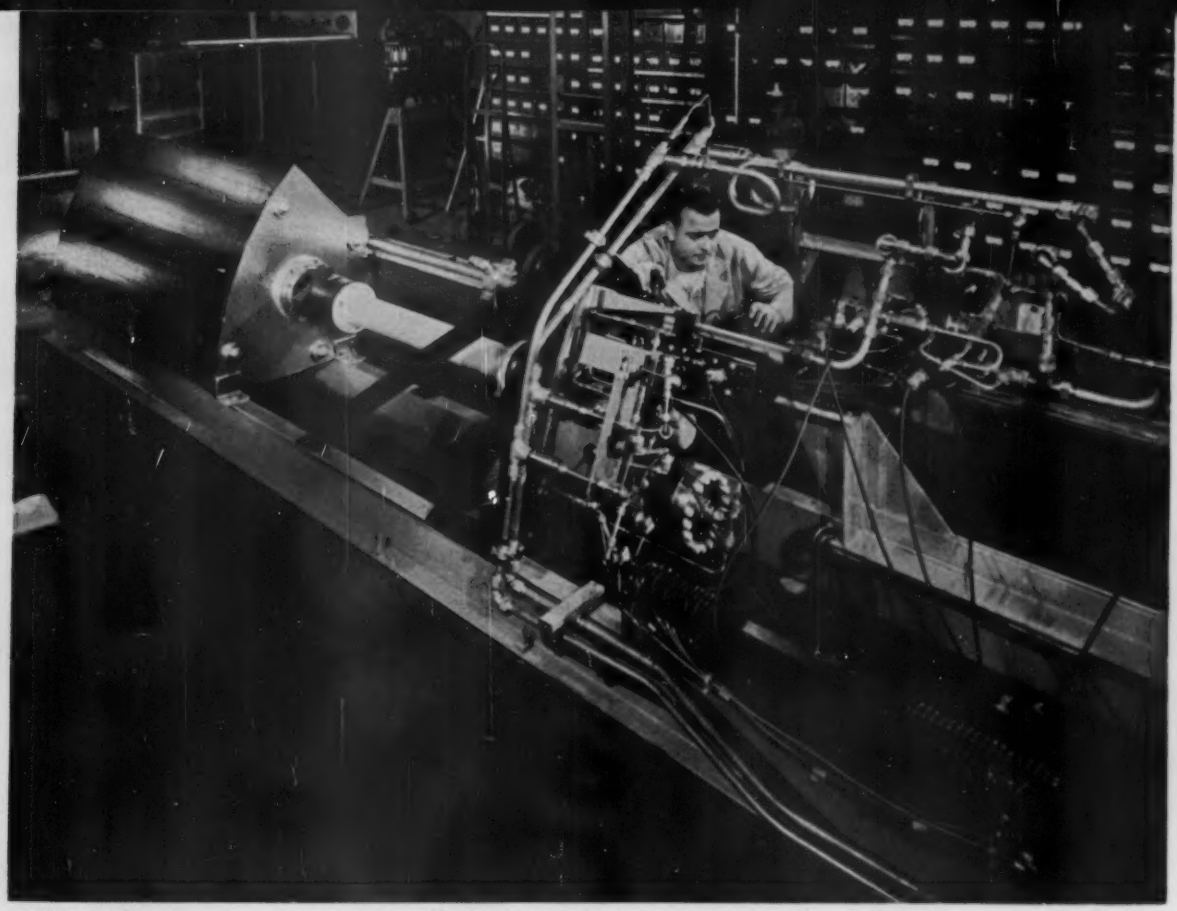
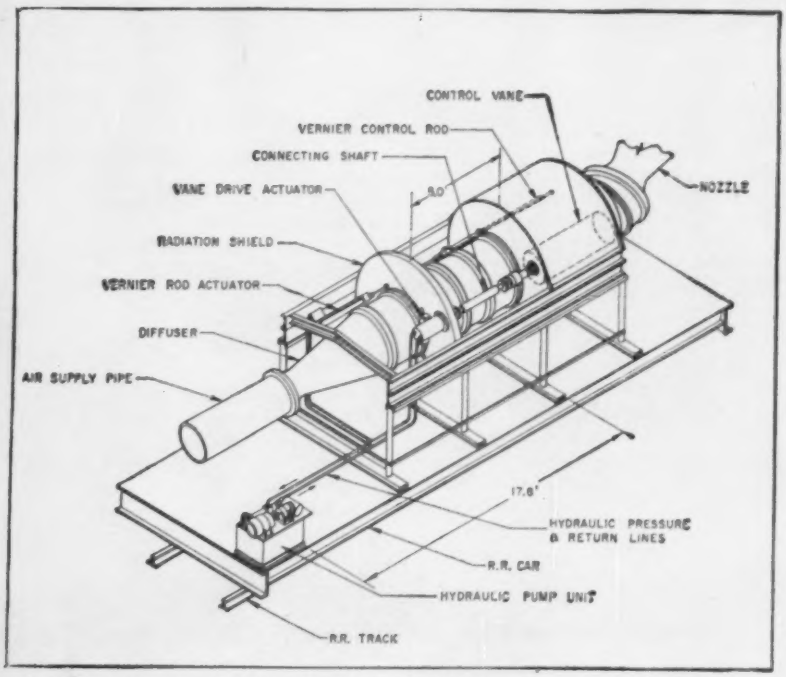


MOCKUP of Tory II-A shows the control element and actuator test components. Airflow through the reactor can approximate conditions found at low altitudes in the Mach 3 speed range.

Tory II-A Engineering Test Reactor Aids



TORY II-A reactor, seen in above drawing, is the first complete reactor to be designed for and tested as part of USAF's nuclear ramjet program.

Los Angeles—Demonstration of the progress being made toward nuclear ramjet flight will be given by runs scheduled for November with Tory II-A, engineering test reactor which is part of USAF's nuclear ramjet program, Project Pluto.

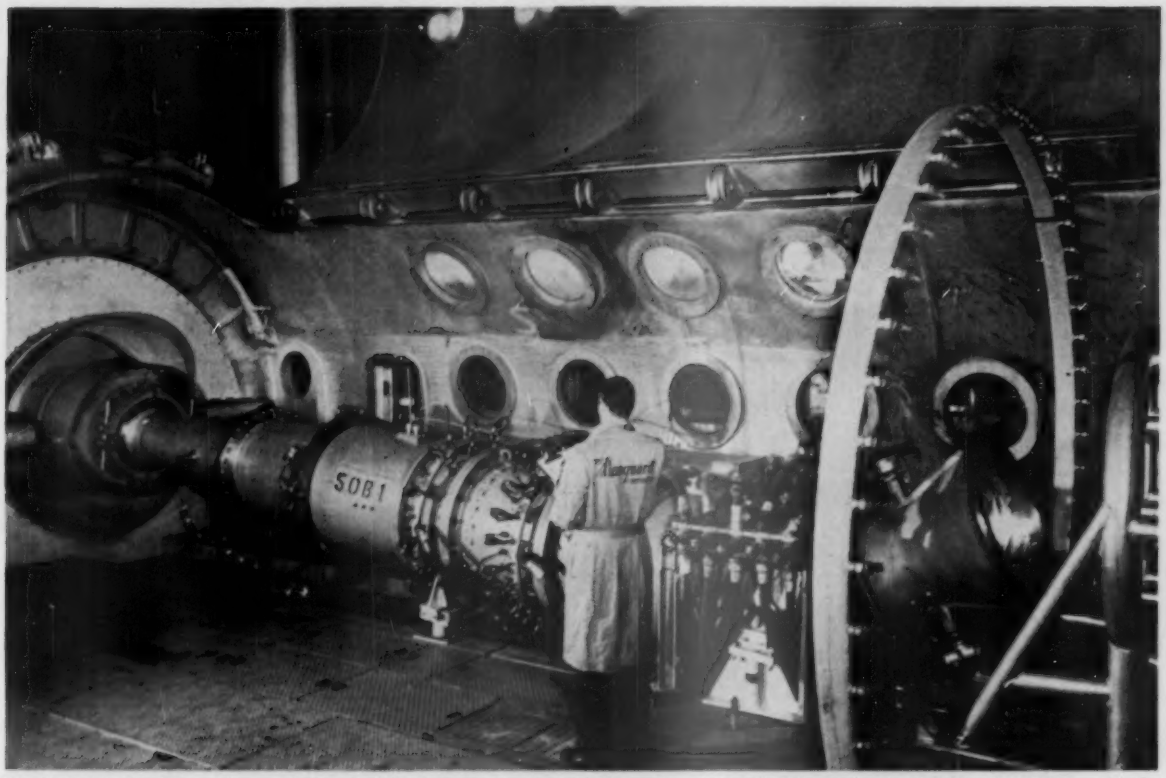
Tory II-A is not flight-type hardware, but its design requirements, coupled with the conditions under which it will be tested, are keyed closely to actual flight conditions.

Engineering Test

Tory II-A is the first complete reactor to be designed for and tested as part of Project Pluto. Originally it was aimed at proving that a ramjet-type reactor could be built in terms of the physics involved. However, it now is described as an engineering test reactor (rather than a feasibility or proof-of-principle device), by Lawrence Radiation Laboratory's Dr. Theodore Merkle, technical director of Pluto.

Although no specific details have been released, key features of Tory II-A reactor core design and testing will probably be along these lines:

• **High power-density,** air cooled reactor core will use a homogeneous fuel-



TORY II-A boilerplate engine, with chemical heat source in place of the reactor, is installed for testing in Cell No. 8 at Marquardt's Jet Laboratory. Reactor core configuration will be a cylinder about 10 ft. long and 10 ft. in diameter.

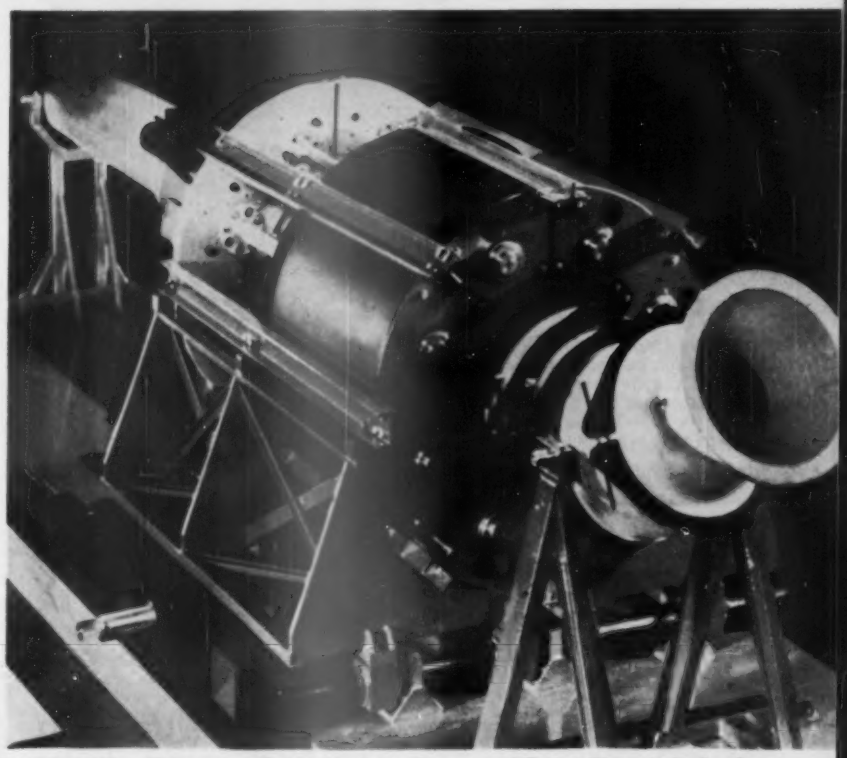
Project Pluto

moderator element, fabricated in a single unit. The moderator, a material which slows down neutrons produced in the fission process without absorbing them, will probably be beryllium oxide, for its nuclear and chemical properties, with enriched uranium or plutonium as the fuel.

• **Reactor core configuration** will be a cylinder, with length about equal to the diameter, expected to be close to 10 ft. Numerous small axial air passages through the core will accomplish heat transfer by forced convection to get high working-fluid temperature.

• **Air flow** through the reactor can closely approximate the conditions resulting from speeds in the Mach 3 range at low altitudes. The test facility has a stored-energy heater rated at 1,000F to preheat the air, a diffuser ahead of the reactor to produce choked flow for reactor high power runs, and can inject a maximum air mass flow of 1,000 lb./sec.

Tory II-A reactor control system has a limited application to flight hardware. It incorporates a fast-reset feature which reduces reactor power quickly, as in a "scram" (complete shutdown), but is nonlocking, and as soon as transient



MODEL of Tory II-A reactor, designed and tested as part of Project Pluto, is displayed at the Lawrence Radiation Laboratory. Test conditions have been closely identified with actual flight conditions, although Tory II is not yet in hardware stage.

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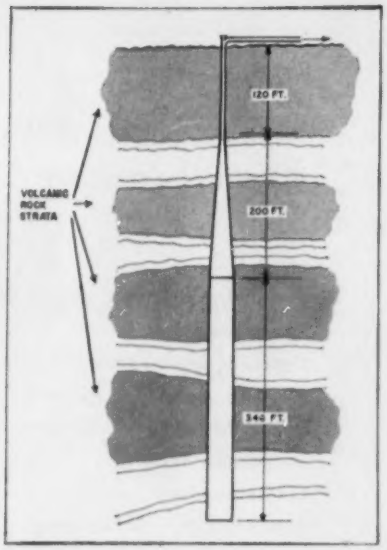

PROPOSED air storage system would utilize strength of rock strata to help carry 3,600 psi. loads of storage air pressure.

conditions causing operating limits to be exceeded are remedied, normal operations are resumed automatically. The fast reset system responds quicker than the scram system in Tory II-A. A scram in the reactor during high power runs could damage core components seriously by thermal shock.

Tory II-A Reactor Control System was described by Robert E. Finnigan of Lawrence Radiation Laboratory, at the semiannual meeting of the American Rocket Society in Los Angeles. Lawrence Laboratory, operated by University of California for the Atomic Energy Commission, has charge of reactor development for Project Pluto.

Power level of the Tory II-A reactor is maintained with 12 neutron-absorbing elements located symmetrically about the core—eight identical control cylinders having high neutron-absorbing material on 120 deg. of their circumference. These are rotated to raise or lower neutron absorption, in addition to the action of four identical neutron-absorbing control rods which move in and out of reactor.

Reactor Controls

The eight control cylinders, called shim vanes, set the reactor operating power level and compensate for reactor temperature change. One of the control rods operates as a vernier, also to maintain reactor operating power level. Two control rods are used as safety units which act in a fast reset mode to resist fast positive changes in reactor power level. The fourth rod can be used as a spare vernier or safety rod, or as an oscillator. When used as an oscillator, it will measure frequency response of the reactor, produce reactiv-

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ity perturbations to check control system performance and determine the worth of the shim vanes.

All control elements function in four basic modes—manual, automatic, fast-reset and scram. Manual operation can be maintained with a servo or override control. Automatic, fast-reset and scram modes are controlled by feedback loops from key sensors in the reactor instrumentation system.

Each control element has its individual electrohydraulic actuator. Normal operation is with vanes and vernier rod in parallel. Loss of one element does not endanger the entire reactor since remaining operating elements can make up for the lost element. An override actuation subsystem with a separate energy source also is provided for each element as a backup.

Radiation-resistant materials capable of withstanding the high fluxes expected are used on control components near the reactor, with no organic materials in the region of 5 to 10 ft. from the reactor inlet.

Variables which Tory II-A reactor control system must hold within limits are reactor power level, the minimum period (time required for neutron density to change by a factor of 2.718), and core component temperature. The control system works by controlling the reactor power level, the inverse period and air flow rate through the reactor. Reactor power level and inverse period are controlled by the rods and vanes, but the air flow rate is programed independently during reactor operations.

Air Flow Control

To prevent interaction between power level and air flow control systems, the diffuser isolates the air supply from the reactor when choked flow is being maintained, and in addition, the frequency response of the air flow control system is designed to be lower than that of the power level control system. Thus, air flow is constant through the reactor during fast power-transients in the Tory II-A test facility. This is the same situation which would apply in flight. The heat capacity of the reactor is large, making variations of power in the gas stream quite sluggish even though reactor power-generation rates can change very rapidly. Since thrust would change as a function of gas temperature leaving the reactor, the flying nuclear ramjet would change thrust levels and speeds slowly, resulting in approximately constant air flows through the reactor during power transients.

Operating requirements for the Tory II-A control system include:

- **Raising reactor core** temperature from ambient to maximum design temperature in quasilinear fashion in about 5 min.
- **Producing a 5% change** in core fuel

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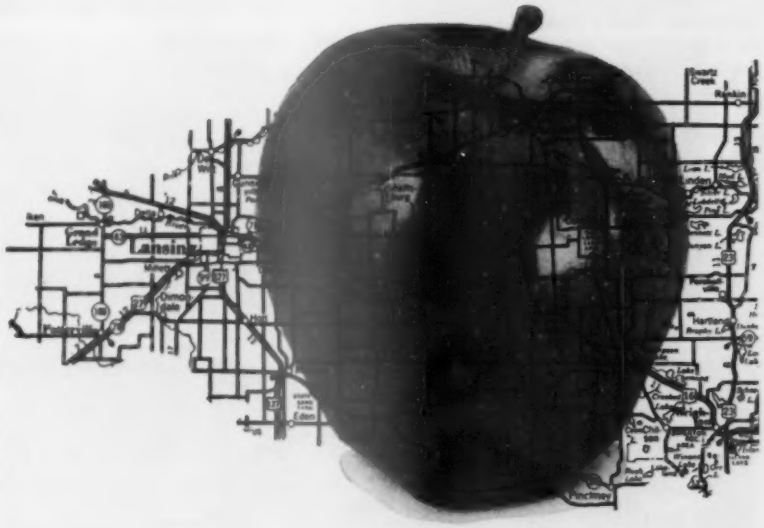

*Solution to the problem: First of all, determine where you are (if you are already in East Lansing, no fair). Take three apples of equal size and give them to your wife (if you have no wife, this is fair enough). Suggest baked apples. Some people prefer them with raisins, which add a delectable flavor, a new dimension, so to speak, especially when covered with thick cream. Have Johnny over for a drink and thank him for the apples. Call an airline and ask them how long it will take you to get to East Lansing, Michigan.

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DIFFUSER which separates air supply from reactor inlet at test facility is machined by numerical control at Marquardt for high accuracy.

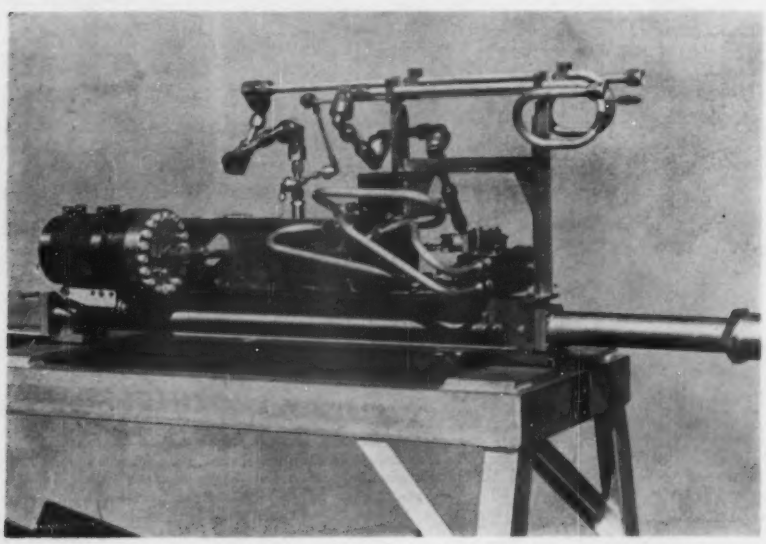
element temperature in five seconds.

- **Holding core fuel element** temperature within 1% of the desired value.
- **Taking reactor power level** from 0.01 to 10 kw. in 10 min. under manual control.
- **Boosting reactor power** from 10 kw. to 10 mw. in 1 min. under manual or automatic control.
- **Altering reactor power** from 10 mw. to full power in approximately 15 sec. under automatic control.
- **Reducing reactor power** from full to 10 mw. in 15 sec. under automatic control.
- **Maintaining power level** within 1% of desired value.

During a typical Tory II-A full power run, the reactor will be brought to critical level and taken to 10 kw. under manual control in about 10 min. The control system then is put in the automatic mode, and after core temperature has reached 50% of design maximum, power will be programed to rise from 10 kw. to 10 mw.

Core Temperature

The core temperature reaches maximum in the 10 mw. power level range with a low air flow rate (a situation which would parallel flight conditions where power level builds up during lower speeds and air flow rates). As the



ELECTROHYDRAULIC actuator is used for Tory II-A shim vane control element.

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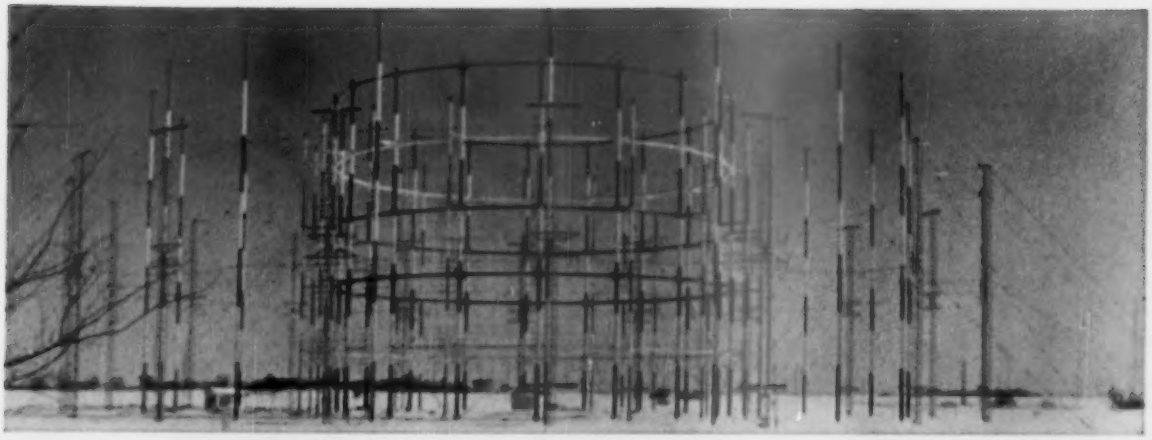

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reactor changes from 10 mw. to full power, air flow is programed concurrently to maintain approximately constant core temperature.

Instrumentation Function

Inputs for the Tory II-A control system are furnished by parts of the same instrumentation system which gathers the data for the record during the run.

The Tory II-A instrumentation system was outlined at the ARS meeting by C. S. Barnett, H. C. McDonald and P. M. Uthe, of Lawrence Laboratory.

Physical quantities which the instrumentation system measures include:

- **Reactor core** neutron flux level and time rate of change of flux level.
- **Air flow** through the reactor.
- **Air temperature** and pressure distribution at the reactor core entrance and exit.
- **Material temperature** distribution in the core.
- **Dynamic and static strain** (stress) in core support structure.
- **Vibration** of large structural components of the reactor.
- **Operating temperatures** of auxiliary components.

Neutron flux level and time change rate information, gas temperature and pressure measurements in conjunction with material temperature measurements in the reactor core are used in feedback loops for reactor control. Temperatures of auxiliary components during operation also are a safety-of-operation feature, hence these temperature indications too are considered part of the control system for emergency situations, although they are expected to have little or no effect on operating characteristics of major core components.

Air flow and heat transfer characteristics of the reactor are determined partly by air temperature and pressure distribution at reactor extremities and air flow rate through the reactor. Core component temperature measurements are used to complete the determination of heat transfer and friction factor characteristics.

Measuring Strain

Core support structure strain is determined at design pressure differentials before high temperature and power are applied. Results of these measurements are used to predict the safety of the structural system when subjected to design loads.

The strain gages in Tory II-A will not be operative at design high temperatures.

Velocity and acceleration pickups will be used on core support structure and air ducts to determine vibrational characteristics of the reactor. These Tory II-A measurements are focused on

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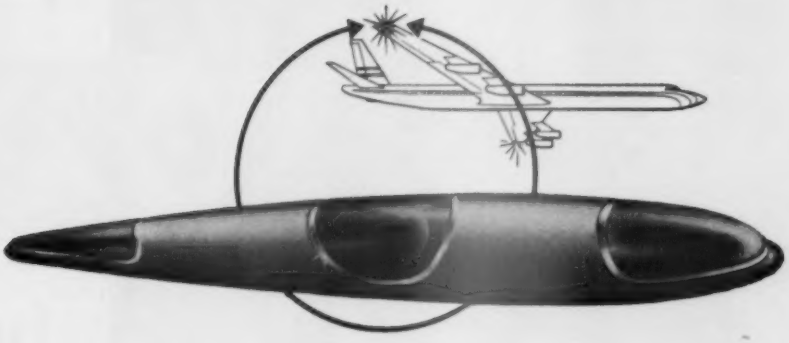

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The new Honeywell-Atkins Maximum Safety Light System is fully compatible with existing lighting equipment. It does not require their alteration or removal, but rather, it adds to the intelligence generated and the range of observation. This new aircraft lighting concept has been accepted by the Federal Aviation Agency, and proven in numerous flight evaluations. Systems are now in service on many aircraft—commercial, corporate, and military. The system is being released for the Electra, 707, DC-8, 880, DC-7, DC-6, 440, 340, Viscount and others, and will soon be available for application to all modern aircraft. For more information relating to this new aircraft lighting system and your specific aircraft requirements, write Honeywell, Aeronautical Division, Department AW-6-127, 2600 Ridgway Road, Minneapolis 13, Minnesota.

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system safety, and little effort will be placed on detailed reduction of vibration data, barring unforeseen circumstances.

Temperature information in the Tory II-A reactor and test system will be gathered by a total of 243 thermocouples which will measure changes from room temperature to the range of 2,000F to 3,000F. Bulk of the measurements are made from core fuel elements and structural parts of the reactor.

Pressures will be measured up to 600 psi.

Information Displayed

Information from the several key measuring systems which function in the automatic control mode to initiate a fast-reset or scram also will be displayed to test facility operators for use during manual control mode operation. A selector switch will permit changes in the type of variable which would automatically initiate the fast-reset or scram, since different parameters gain and lose their importance according to reactor operating power level.

Design and construction of the intermittent (blowdown) air supply system for Tory II-A test facilities was done by Marquardt Corp. under its contract with USAF on Project Pluto. Since a ramjet does not pump air through itself like a turbojet a blowdown system is usually required to obtain the speed/altitude/pressure profiles a ramjet encounters in flight.

Air Storage Proposal

Test periods of 2 to 3 min. have been obtained in conventional ramjet blowdown test facilities, where a primary limit is air storage. For Tory II-A test facility, Marquardt has investigated rock strata under the test site area. If test borings substantiate calculations on nature and strength of the strata, Marquardt proposes to store air in underground vertical shafts. Substantial cost reduction could be made if the rock is strong enough to carry a significant part of the load created by the 3,600 psi. at which the air is stored.

Marquardt has been working on Pluto and Tory II under various contracts with USAF since 1957. Work has included conducting research leading to development of a nuclear ramjet, development of non-nuclear components for Pluto, and the design and construction of the air supply system for Tory II-A test facility. Tory II-A work also included building a "boilerplate" engine for the reactor test facility, which has been tested in Marquardt's conventional ramjet test cell No. 8, using a chemical heat source to replace the nuclear reactor.

Specific problems associated with nuclear ramjet development and ap-

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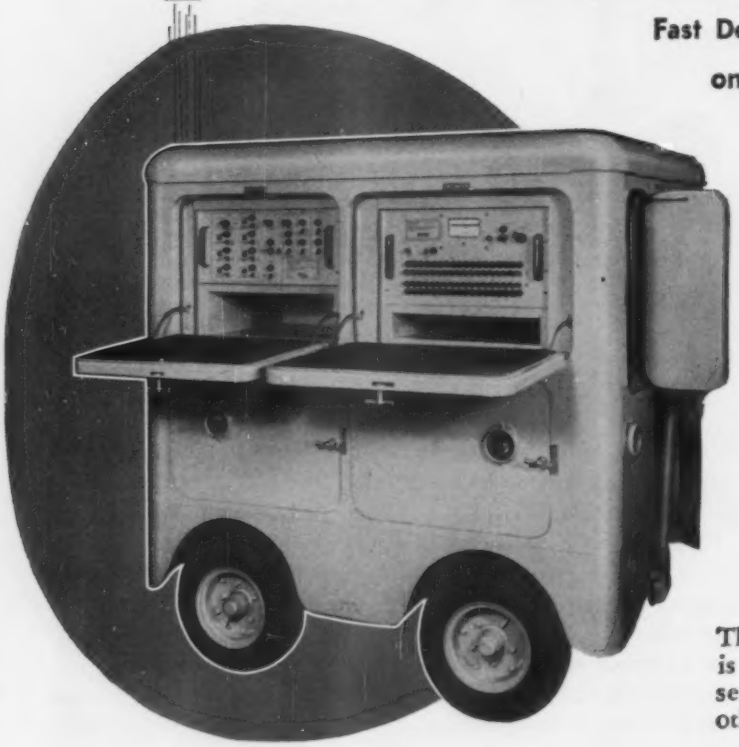

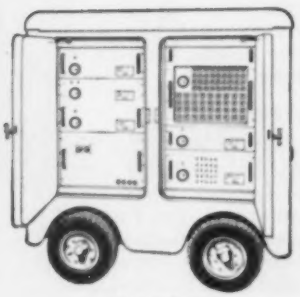

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proaches to solving them have been discussed by Dr. Merkle, and by Alan R. Gruber, director of Nuclear Systems Division of Marquardt Corp. in the Air University Quarterly Review of the Air University at Maxwell Air Force Base.

Design Constraints

Nuclear properties, their relationship to and effect on materials, form the major constraints on design approaches to solve nuclear ramjet problems, and there are the usual economic and technical limits facing any new design.

Most difficult problem areas of nuclear ramjet reactor development listed by Dr. Merkle include:

- **Mechanical properties** of high temperature ceramic (light metal oxides and certain carbides) moderator materials, which must be developed to a high degree of reliability in production form. These materials, extremely brittle and hard, must withstand high aerodynamic pressures while operating under severe thermal stress.
- **Technique** for distributing (imbedding) the fuel in these ceramic materials which will have to be evolved. The combination of distributing technique and materials must provide that the mixture will not leak fuel at high temperatures, and it is desirable that fission fragments be contained as well. The homogeneous moderator-fuel mixture must have characteristics so that chemical attack by the air moving through flow passages of the reactor core at high velocity and temperature will not unduly limit life of the reactor.
- **New fabrication** methods to be developed if reactors are to become significantly less expensive than they now are. This will require manufacturing practices, product control methods and inspection techniques of a new sort.
- **Testing** to prove adequately components and subassemblies of full size reactors as well as items in any proposed missile, which will have to be developed, with special attention to the intense radiation environment. Building full-scale reactors for this purpose would be extremely expensive.

Heat Generation

A direct, open-cycle nuclear ramjet uses its reactor as the heat exchanger as well as its energy (heat) source. Over-all system efficiency is a direct function of heat transfer capabilities.

For nuclear ramjet purposes, the necessary heat can be generated by two types of reactors, which are defined by the energy class of the neutrons they use to sustain the chain reaction, as "fast," (unmoderated) and "thermal" (moderated) reactors.

Because they move so fast, the neutrons of the fast reactor tend to miss the nuclei of the fissionable material

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which they must strike to keep the splitting process going, so a more efficient (and costly) type of fuel must be used in this type reactor core. Also, a greater total quantity of fissionable material must be present in the fast reactor core.

Fast Reactor Features

A fast reactor has a small critical size, the over-all volume required to contain sufficient fissionable material to sustain the chain reaction. Both the fast and thermal reactors make use of neutron reflectors around the core to reduce the inherent neutron leakage from the reactor, thus increasing core efficiency.

The fast reactor has a high power-density, and gives the greatest heat yield per cubic centimeter, which reduces reactor weight. Another fast reactor feature is that its fast-moving, high-energy neutrons are not subject to absorption by very many materials, thus allowing a wide selection of reactor structural and auxiliary materials.

However, controlling a fast reactor by conventional neutron-absorbing rods is impossible, although control might be accomplished by manipulating fuel elements in the core as an additional way to reduce neutron leakage over and above the normal reflector.

In addition, the smaller size of the fast reactor reduces available heat transfer area, limiting over-all efficiency.

Fuel Cost

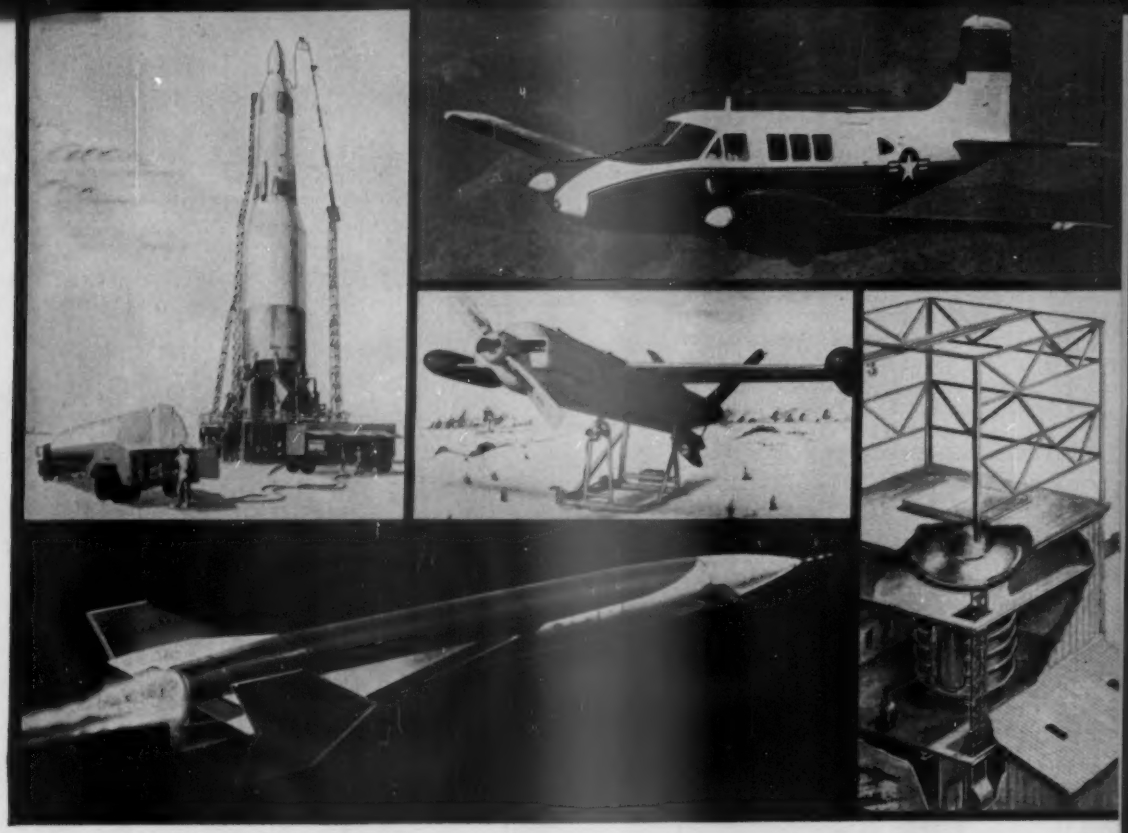
The cost of fuel for a fast reactor to be used in a nuclear ramjet propulsion system would be extremely high for any reasonable vehicle size. This very significant disadvantage of a fast reactor places the moderated type in the forefront.

The moderated reactor needs a significantly smaller total quantity of fissionable material than the fast reactor (less by a factor of 100 in cost), since the slower-moving "thermal" energy neutrons have a greater chance of striking the target nuclei and sustaining the chain reaction.

The moderated reactor can carry its fuel in separate elements surrounded by the moderating material—a heterogeneous moderated reactor—or mixed throughout the moderator homogeneously. Problems of containment for heterogeneous reactor fuel elements have given the lead to the homogeneous approach.

Problems facing the homogeneous moderated reactor, in addition to those of mechanical properties, mixing methods and fabrication techniques mentioned earlier, include the variation in degree of criticalness as the core temperature varies from ambient to high operating values.

This variation may be equivalent, during warmup, to using up to 50%



Imaginuity*

* A coined word adopted by Beech Aircraft Corporation to express its design, development and production accomplishments and capabilities in such diversified, yet related, aerospace fields as:

- Airframes and airframe components
- Missile target and reconnaissance systems
- Complete missile systems
- Electronic guidance systems
- Cryogenics and environmental testing of missile and space vehicle systems and components
- Programs pertaining to liquid hydrogen propellants, liquid hydrogen storage and cryogenic fuel tank systems
- Ground support equipment for the aerospace age
- Research and Development programs requiring advancements in existing state of the art development relating to the missile and space field

For examples of Beech Imaginuity, see the next 5 pages

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BEECH "IMAGINUITY" IN *Cryogenics*

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3
BY "BURNOUT" TIME, vital information that will influence future design of complex cryogenic fuel systems has been gathered for processing through electronic computers—all without ever leaving the ground!

2
AS "MISSILE" ACCELERATES, fuel is programmed out of the tank and outside pressure reduced, while temperature can be elevated to as high as 1,000° F to simulate actual conditions of fuel consumption and aerodynamic heating. Temperatures of 1,500° F or more can be produced.

1
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DESIGNED FOR LAUNCHING BY AIR, GROUND OR FLEET SURFACE UNITS

Beech XKD2B-1/WS462L: Winner of Navy/Air Force design competition . . .

Mach 2 target system for realistic training born of Beech cryogenic + airframe experience

Designed to simulate the speed, altitude and target characteristics of enemy aircraft, the Beech XKD2B-1/WS462L makes possible effective testing of advanced weapons systems and provides realistic training—at low cost—of air, ground and fleet defense units. Into its development has gone more than 6 years of Beech experience in cryogenics, plus over 27 years of airframe know-how. With its pre-programmed guidance system, it operates at altitudes from 1,000 to 70,000 feet and at speeds up to Mach 2. Adaptable for use with Nike, Terrier and Talos launchers, the Beech XKD2B-1 has promising potential for economical development as a missile system. It can carry a substantial payload, to fulfill a wide range of future missions.

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KDB-1 ON LOW COST, PORTABLE ZERO-LENGTH LAUNCHER

Beech Army/Navy KDB-1: Versatility at low cost . . .

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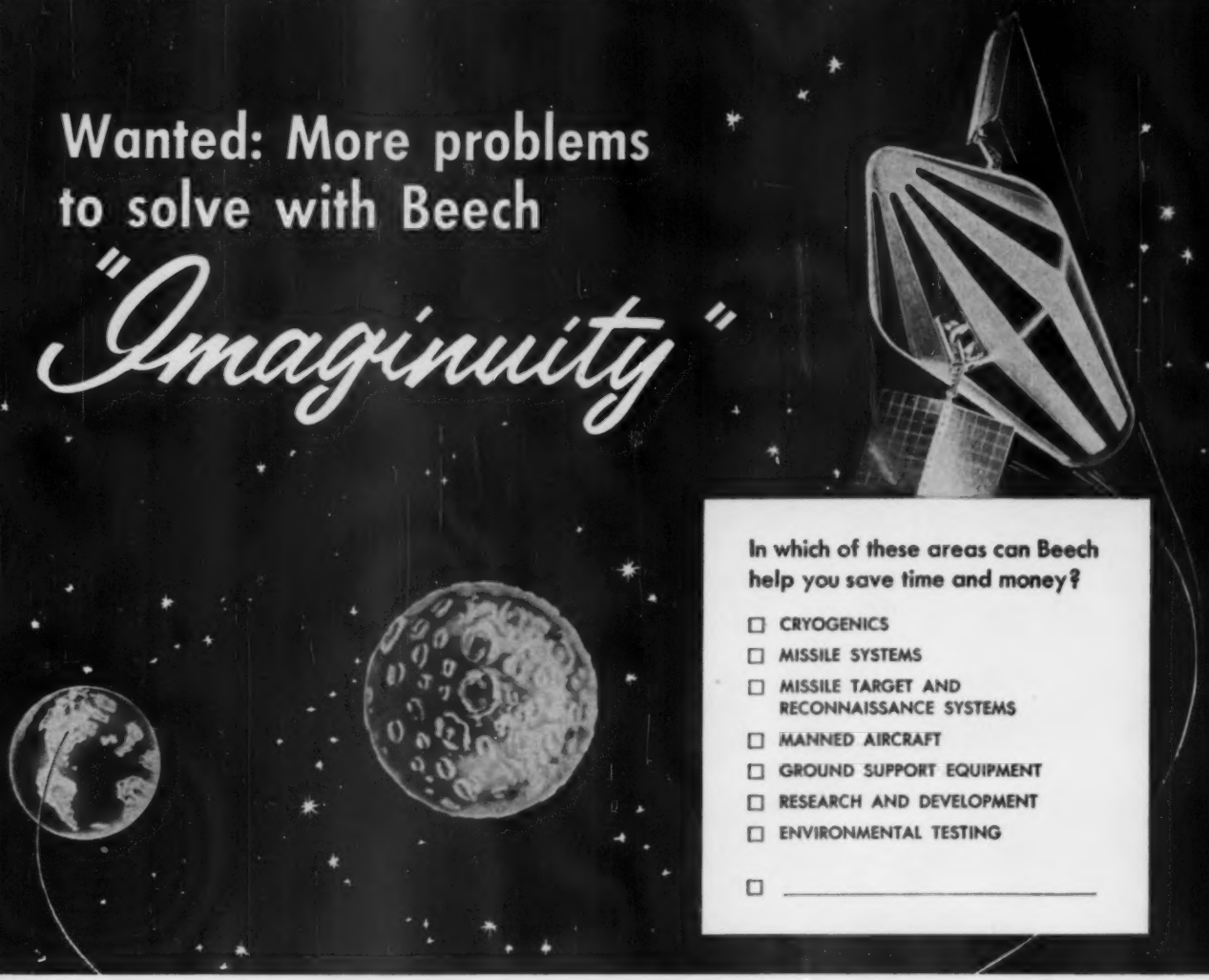

In which of these areas can Beech help you save time and money?

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Through a planned program of "unified diversification," Beech Aircraft Corporation has developed proven design, development, fabrication and testing capabilities which give it a "head start" on many problems and projects related to the missile and aerospace age. Beech Aerospace Division projects include R&D on manned aircraft; missile target and reconnaissance systems; complete missile systems; electronic guidance systems; programs pertaining to liquid hydrogen propellants and cryogenic tankage systems; environmental testing of missile systems and components; and GSE. May we help you? Write, wire or phone Contract Administrator, Beech Aircraft Corporation, Wichita 1, Kansas—or one of the area offices listed below.

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more fuel in the reactor to maintain criticality, than required for nearly constant temperature operation. This might be alleviated by a "hot moderator," but no reactor has been run yet using this approach.

Negative Temperature

The combination of fuel quantity and temperature effect give this type of reactor a large negative temperature coefficient of reactivity, a condition when reactor core temperature increases, fuel density decreases, lessening the chance for moving neutrons to strike their target nuclei and sustain the chain reaction.

A large negative temperature coefficient of reactivity has advantages and disadvantages. An advantage is that if the reactor starts to run away, the power increase gets the core so hot that reactivity drops off and shuts down the power increase. A disadvantage is that excess reactivity potential created by the large fuel quantity makes a wide "control swing" necessary to regulate reactor power level.

Gruber's analysis lists general considerations, many of which apply to both nuclear and conventional heat sources.

Assumptions include a solid reactor core with many small axial air passages through it, where forced convection heat transfer occurs. Transferring sufficient heat to the working fluid incurs a pressure drop caused primarily by friction.

That part of the reactor frontal area available for air flow is the void dracction, which in combination with the Mach number at reactor inlet forms a significant parameter for the relationship of reactor cross-sectional area to the engine's free stream capture area.

Problem Areas

The nuclear ramjet must include a number of design compromises which solve the problems with a minimum of engine efficiency loss. Problem areas include:

- **Achieving sufficiently high** air temperatures in a reactor of reasonable size without subjecting the core to critical thermal stresses and causing a pressure drop which cannot be compensated by the inlet-exhaust nozzle combination.
- **Economical reactor core** producibility. Thus, air mass size must be attained within reasonable manufacturing tolerances. Fuel quantity/moderator ratios must allow formation of a unit which will successfully withstand flight loads either by itself or by a proper mounting system, using materials which operate successfully in the high oxidation environment yet have the required nuclear characteristics.
- **Requirement** for a high degree of flight and engine control integration, which tends toward increased complexity and lowered reliability. Aerodynamic flight conditions will have a significant effect on engine operations. A reactor has a high heat capacity and large mass, and while power level changes can be made rapidly, translating these into changes in thrust level is very sluggish.

Degree of coordination necessary between reactor power level, inlet-exhaust nozzle and aerodynamic flight controls is illustrated by the condition that, should a sharp directional change occur, as might be caused by a vertical gust, the inlet will ingest a different quantity of air, changing the temperature profile across the reactor heat transfer area and cause thermal shock damage to the core or a wide swing in power level due to temperature change. Exhaust velocity (thrust level) would be changed, in turn starting another cycle of changes. The integrated control system will have to respond in the right amount in the proper areas at the right time.

- **Radiation environment,** which will affect the physical and mechanical properties of materials in the area of the reactor and its associated controls. The radiation also will cause significant heating in the adjacent areas, adding to the aerodynamic heating resulting from the vehicle's high speed.

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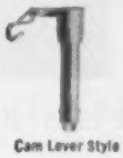
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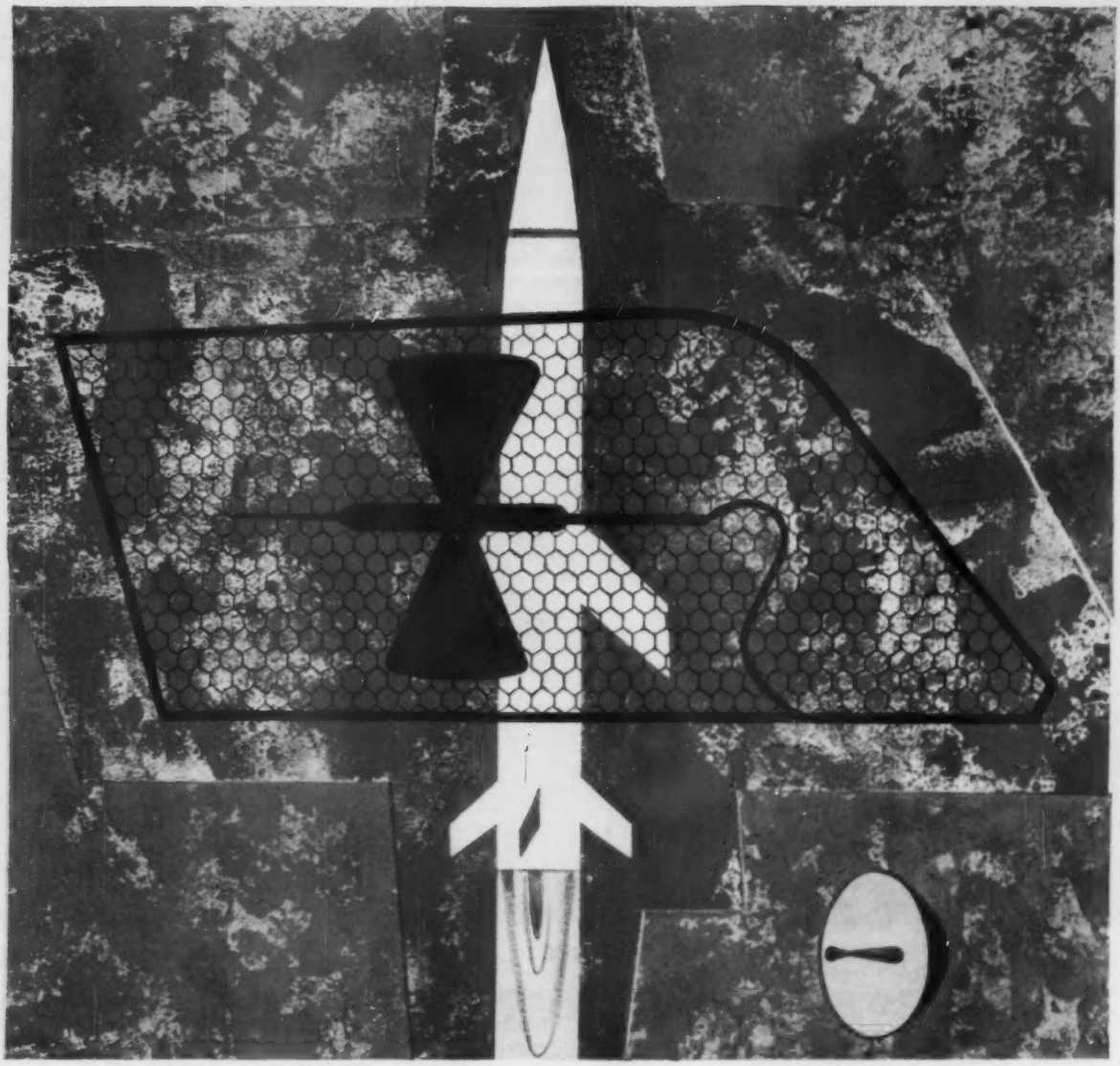

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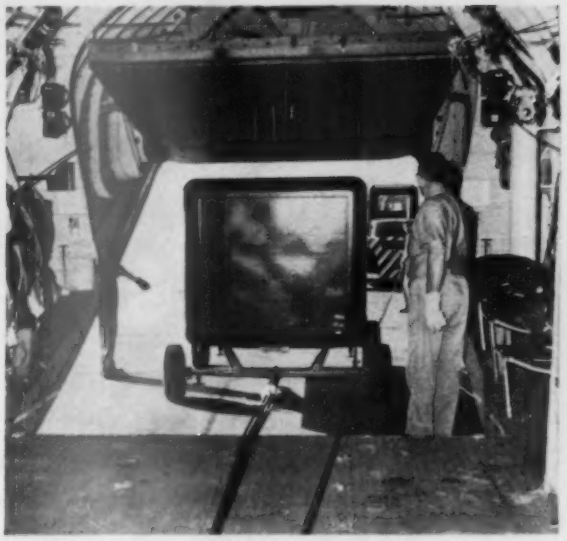
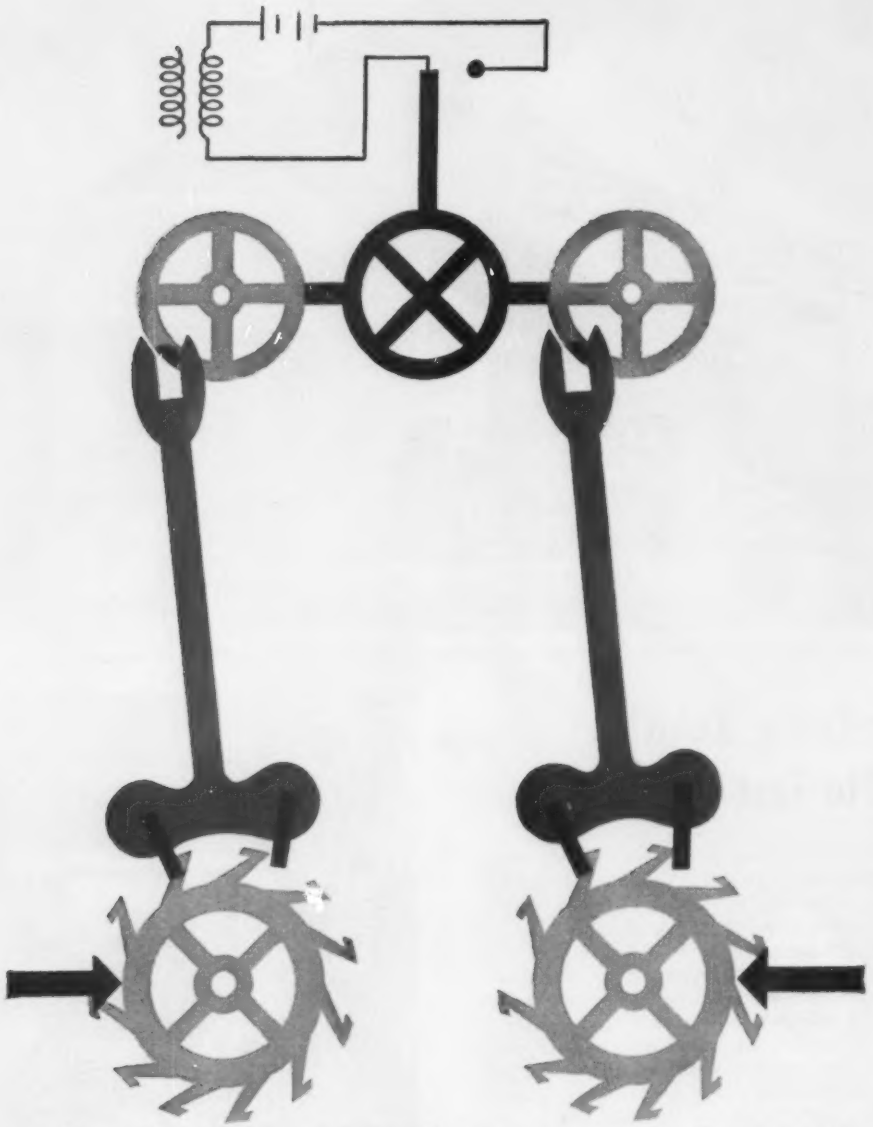
Mobile trailer carrying Avco re-entry body is loaded into a Fairchild C-123 transport through its rear cargo door.

Titan Re-Entry Vehicles Airlifted to Test Site

Air shipment of Titan re-entry vehicles from Avco Corp.'s Lycoming Division at Bridgeport, Conn., to Air Force Missile Test Center at Cape Canaveral, Fla., involves use of a support trailer which carries the vehicle from the plant to the aircraft, in this case a Fairchild C-123 transport. At the Cape, an Avco team removes the re-entry vehicle for checkout and installation on a missile. Vehicle is first mounted on an Air Log ground handling dolly, whose height is calibrated for loading into the mobile trailer (AW June 6, p. 33). System is extremely precise to ensure against scratches or dents. The vehicle is loaded on the Air Log dolly mounted in a cradle fitted with a yoke which rotates 90 deg. at the re-entry vehicle's center of gravity. A similar dolly is available at Cape Canaveral to remove the vehicle from the mobile trailer for checkout and the cradle is used for hoisting the vehicle onto the booster. Another container accompanies the trailer and vehicle, carrying support equipment.



Trailer is hauled into the C-123 by the plane's cargo winch (above right). Large loading door is partially retracted (below left) and technicians secure the vehicle. Floor brake is locked down (below right) and trailer is bolted down after center of gravity is checked.



Bulova dual channel balance wheel escapements

Bulova's talent for design, engineering and production of reliable timing devices has secured an important place for these critical mechanisms in our nation's industrial and defense communities.

The timing regulation of the sophisticated system shown above is based on the action of a simple balance wheel escapement. For every complete oscillation of the balance wheel, the levers permit scape wheel to advance one tooth according to the following.

In any given escapement, the principal variables which must be established are:
balance wheel frequency, f_b;
the gear reduction from scape wheel to mainspring, R;
and the torsional spring constant, Q, of the balance wheel hairspring.

The desired time per balance wheel cycle is determined by

(1) $$t = \frac{\beta n R}{2\pi f_b}$$

For optimum scape wheel functions over the range of mainspring torques, it is desirable to use the maximum balance wheel amplitude, just short of overbanking. Thus the balance wheel will have sufficient amplitude, Q, at lower mainspring torques.

The maximum energy imparted to the lever by the scape wheel must not exceed the energy absorbed by the balance hairspring. Therefore

(2) $$\tfrac{1}{2}Q(\triangle\emptyset)^2 \geqq \eta \frac{T_m\,(\triangle\theta)}{R}$$

where η is the efficiency of energy transmission from mainspring to hairspring, T_m, the maximum torque at hairspring, and θ, the angular displacement of the pallet. The factor, η, must generally be experimentally determined.

The third equation takes into account the fact that the balance wheel vibration system exhibits, by its nature, simple harmonic motion. Thus

(3) $$f_b = \frac{1}{2\pi}\sqrt{\frac{Q}{I}}$$

Where I is balance wheel inertia (constant for a given system).

The design procedure involves the choice of a convenient gear ratio and the definition of Q. Once Q is determined, f_b can be found by using Equ. (3). The R and f_b selected must be compatible with t.

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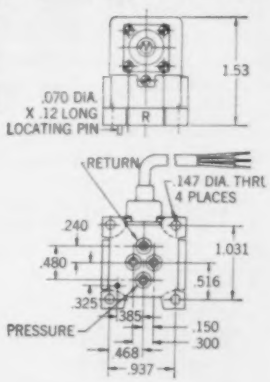

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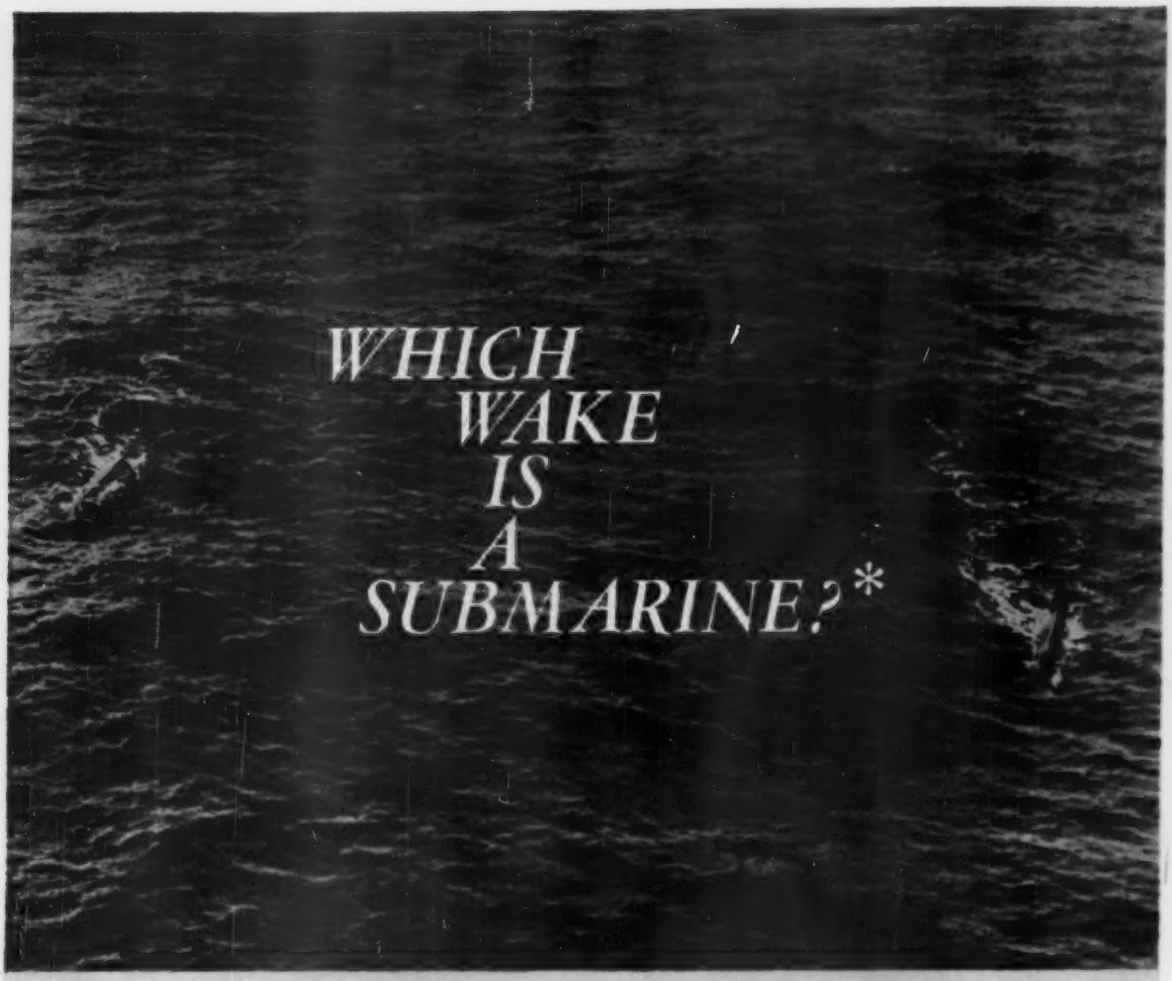

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Ionosphere Probes May Have Wide Effect

By Barry Miller

Melville, N. Y.—Series of upcoming ionospheric sounding experiments is expected to yield knowledge which could have far-reaching effects on long-range communications, detection of ICBM warheads and nuclear detonations, communications with re-entering space vehicles and electronic countermeasures.

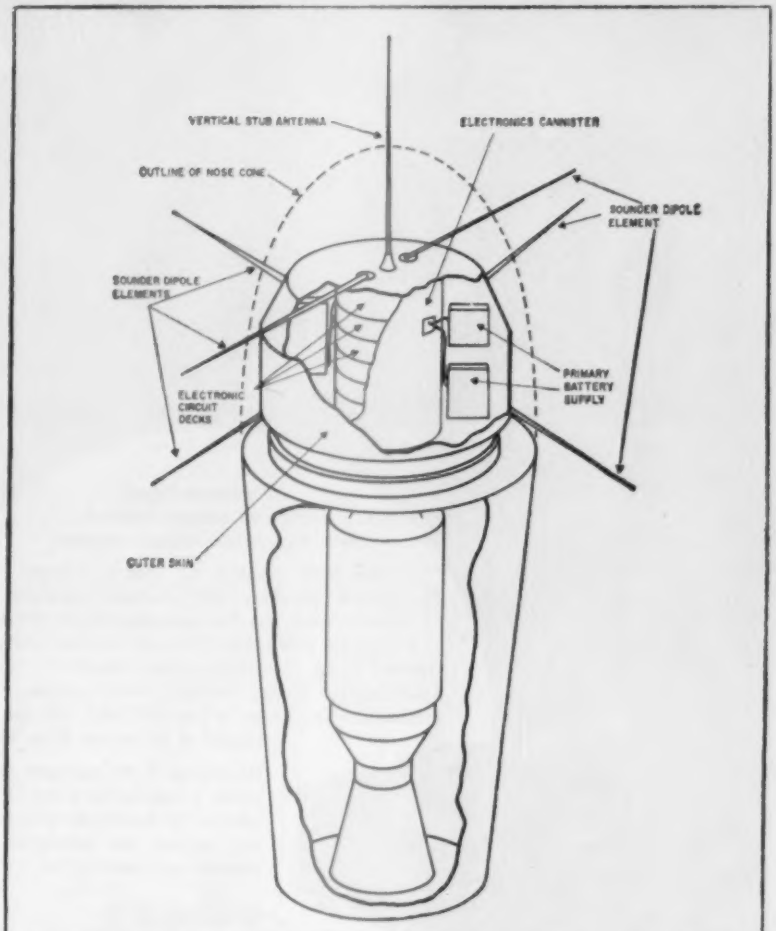
One of the experiments, scheduled for the winter of 1961, will consist of a satellite, launched from the Pacific Missile Range by a Thor-Delta booster, equipped to measure electron density of the ionosphere above the peak ionization of the F_2 layer, roughly 180 to 600 mi. above the earth. Experiment, to be conducted jointly by the National Bureau of Standards and Airborne Instruments Laboratory here, under National Aeronautics and Space Administration sponsorship, is expected to provide scientists with added insight into the physical phenomena affecting electromagnetic propagation above the ionosphere.

Responsibility for the project divides between Airborne Instruments Laboratory and the NBS Central Radio Propagation Laboratory as follows (AW Mar. 28, p. 84): Airborne will design, develop and assemble the experimental hardware, including airborne, ground checkout and display equipment while Central Radio will set the experimental parameters and interpret the results. For its part, Airborne will receive slightly more than $1 million, and Central Radio will get $495,000.

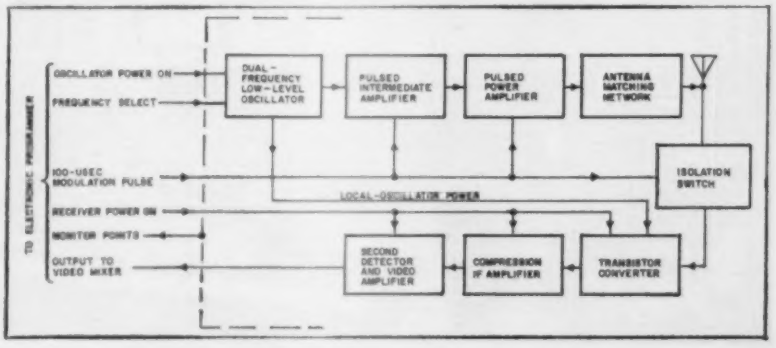
Meanwhile, the Air Force Cambridge Research Center has instructed the Advanced Electronics Center of General Electric's Light Military Electronics Department in Ithaca, N. Y., to ready by January a prototype topside ionospheric sounder, intended for polar orbit launch. This work is backed by a $100,000 contract. Interest at AFCRC reportedly stems from concern with the effects of nuclear detonations on propagation characteristics of the atmosphere.

In addition, the Defense Research Telecommunications Establishment of Ottawa, Can., is cooperating with NASA on a slightly different, but complementary, ionospheric sounder (AW June 22, 1959, p. 139). The Canadian government agency is designing and assembling a payload which NASA is expected to orbit about the same time, or shortly after, the local company's sounder is orbited.

The ionosphere has been probed extensively by vertical incidence type rocket-launched sounders prior to and during the International Geophysical Year. Such ground-based sounders have two severe limitations for regions above peak ionization, however. One is that ionospheric parameters cannot be measured conveniently above the region of maximum electron density. The second is that, as shown during IGY, there are significant variations in electron density with altitude, time of day, season and latitude so that to obtain a truly accu-



SATELLITE-BORNE payload package (above) for topside sounder experiment. Transceiver module of topside sounder employs dual frequency low-level oscillator which serves as local oscillator for returns on two transmission frequencies.



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rate profile many ground-launched rockets, fired from widely dispersed sites, must be employed. These obstacles may be overcome, topside sounder advocates believe, with a sounder located in an orbiting satellite which can radiate comparatively low-frequency signals downward into the ionosphere and interrogate the height of the ionosphere many times a second.

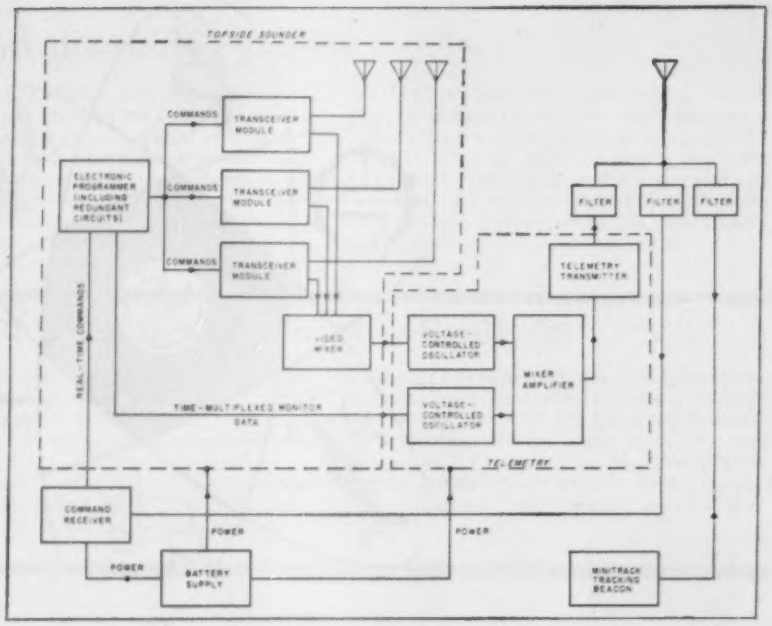
Experiment Objectives

From an adequate number of samples an electron density profile over a substantial portion of the earth can be mapped.

Objectives of the Airborne Central Radio sounding system experiment, with the first two regarded as paramount, are to measure:

- **Electron density** of the ionosphere at 180 to 600 mi. above the earth's surface range.
- **Variation of these parameters** with time of day, season, latitude, and varying degrees of geomagnetic disturbance.
- **Plasma resonance frequency** in the vicinity of the sounder by indirect means.
- **Cosmic noise level** in 3-15-mc. range.

Primary technique for mapping electron density will be to measure the time delay of pulse transmissions reflected back to the satellite from the ionosphere beneath it. Three dual-frequency transceivers contained in the sounder within the satellite will sequentially transmit pulses at six fixed frequencies logarithmically spaced between 3 and 15 mc. The pulses and their echoes will then be telemetered to ground stations on a frequency in the 136 to 137 mc. band.



FUNCTIONAL BLOCK diagram of satellite-borne topside sounder indicates sounder and telemetry equipment enclosed in dotted lines. Telemetry, command receiver, and tracking beacon use the same stub antenna.

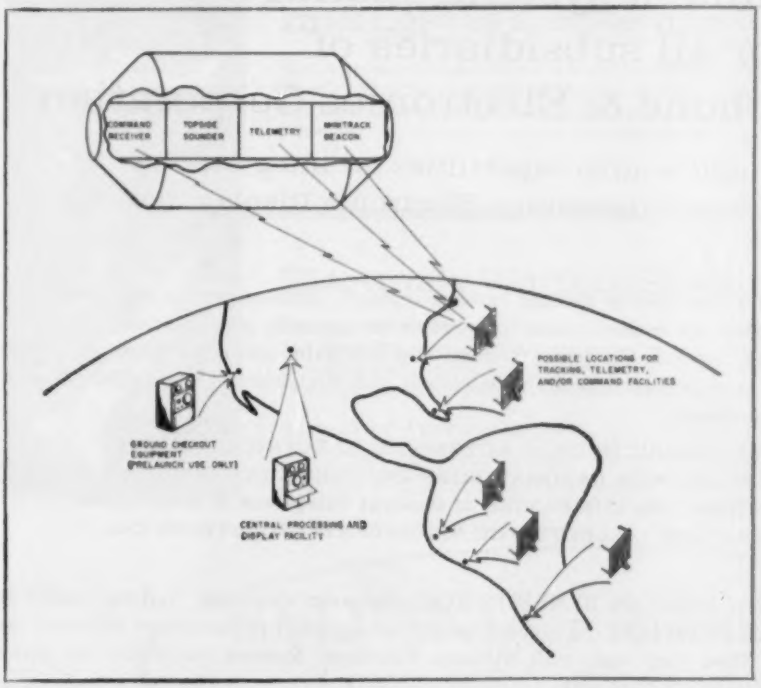
Besides the sounder and telemetry equipment, the satellite is expected to contain a Minitrack or equivalent tracking beacon, which Airborne says is to be supplied by NASA, and a command receiver which enables the vehicle to supplement stored commands with commands in real time from a ground-based transmitter. A single vertical stub antenna may be used for telemetry, tracking and command with individual signals separated by filters. Total weight of the payload is not to exceed 200 lb.

Project Phases

This topside sounder project will evolve in two phases. In the first, a sounding rocket fired from Wallops Island will be an experimental vehicle for checking design and verifying experimental parameters. The second phase will involve an attempt to orbit the topside sounder and associated equipment, capable of one-half to one full year useful life, from the Pacific Missile Range.

A circular orbit inclined at 80 deg. and a proposed altitude of about 600 mi. were selected for the sounder system so that high altitude and equatorial regions might be sampled. Should the system fail to achieve the desired circular orbit, or in the event that its altitude differs from the projected 600-mi. goal, Airborne engineers expect partial success from the experiment in the form of useful soundings of the ionosphere above the 180-mi. point.

Like the Airborne-Central Radio system, the General Electric sounder, also a pulse system, will employ six



TOPSIDE ionospheric sounder experiment jointly conducted by Airborne Instruments Laboratory and the Central Radio Propagation Laboratory of the National Bureau of Standards will supply information about electron density of the upper ionosphere. Satellite will contain telemetry equipment, command receiver and tracking beacon.

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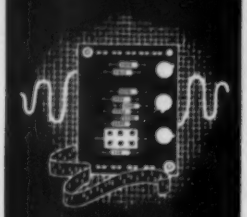

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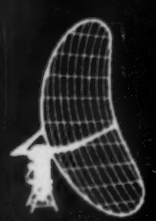

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In recent years, Sylvania has developed numerous types of broadband receivers, signal analyzers, and sensing devices across the entire spectrum. Advanced anti-intrusion devices are now under development. In addition, Sylvania is developing and managing several other highly classified programs in this area.

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Sylvania leadership in electronic warfare is typified by its advances in countermeasures and counter-countermeasures against all known types of electromagnetic radiation. Sylvania manages the passive defense system for the B-58, and maintains a quick-reaction capability and facility for Army ground-based electronic warfare activities.

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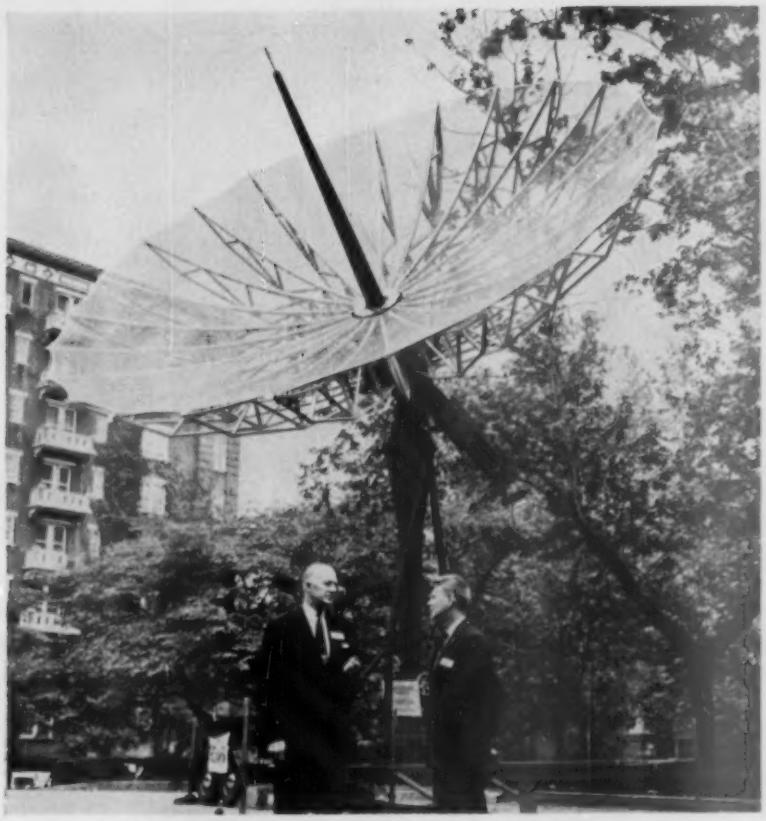


Dish Folds on Tracking Antenna

Portable satellite tracking antenna, with parabolic dish that folds like a Japanese fan, is built on small trailer. Two small hand-cranks are used to position antenna dish. Developed by D. S. Kennedy & Co., portable antenna was displayed at recent Armed Forces Communications and Electronics Association convention in Washington.

discrete frequencies, but will store experimental data in a recorder and use only a single ground station.

The Canadian sounder will be an FM system.

Associated with each of the three dual-frequency transceiver modules in the airborne sounder is an electronic programmer and a dipole antenna. Each frequency is transmitted for 100 microseconds and 15 milliseconds are allowed for echo returns. Each module will be able to operate independently of the others, should one module fail. The two frequencies transmitted by a transceiver module can be selected so that no module transmits adjacent frequencies in the 3 to 15 mc. sequence. Thus the sounding frequencies will still be well distributed over the transmission band should a module fail.

Such a transceiver module has a dual-frequency low-level oscillator, Airborne explains, which provides inputs to pulse-modulated IF amplifier and power amplifier stages and to a transistor mixer stage of a superheterodyne receiver. The oscillator is energized for three intervals, during the first and third of which it operates at one of its two frequencies and during the second it operates at the other frequency.

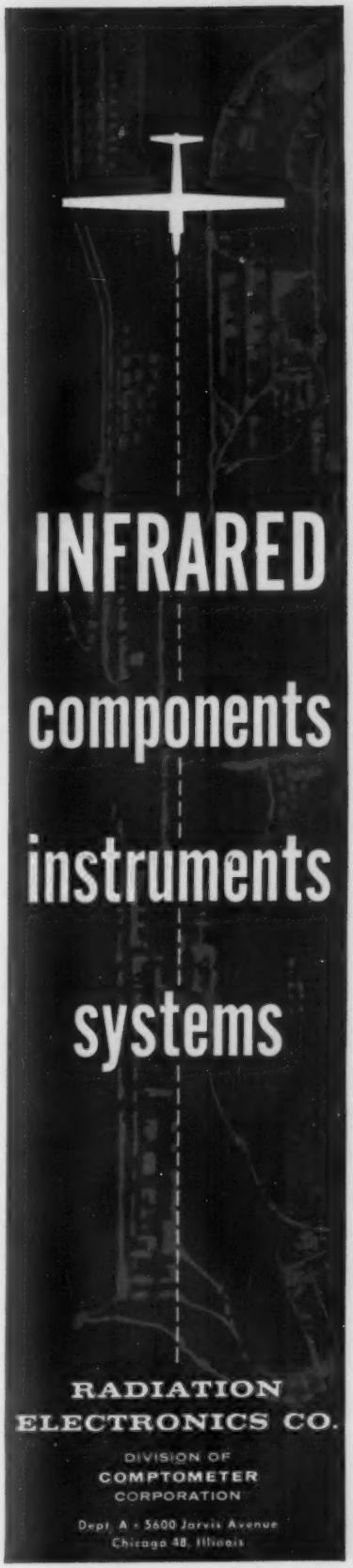
In operation a modulation pulse is applied to the power amplifier stages during the final 100 microseconds of the first pulse interval, thereby causing an RF pulse at the first frequency to be generated. At the conclusion of the first pulse interval, the oscillator switches to the second frequency for the duration of the second pulse interval.

Second Frequency

This second frequency then serves as the local oscillator frequency for echo returns of the first transmitted frequency.

Again during the last 100 microseconds of the second pulse interval, a modulation pulse is applied to the power amplifier stages, generating another RF pulse, this time at the second of the transceiver's two frequencies.

The oscillator then reverts to the first frequency, acts as local oscillator the second frequency returns. The modulation pulse is not applied during



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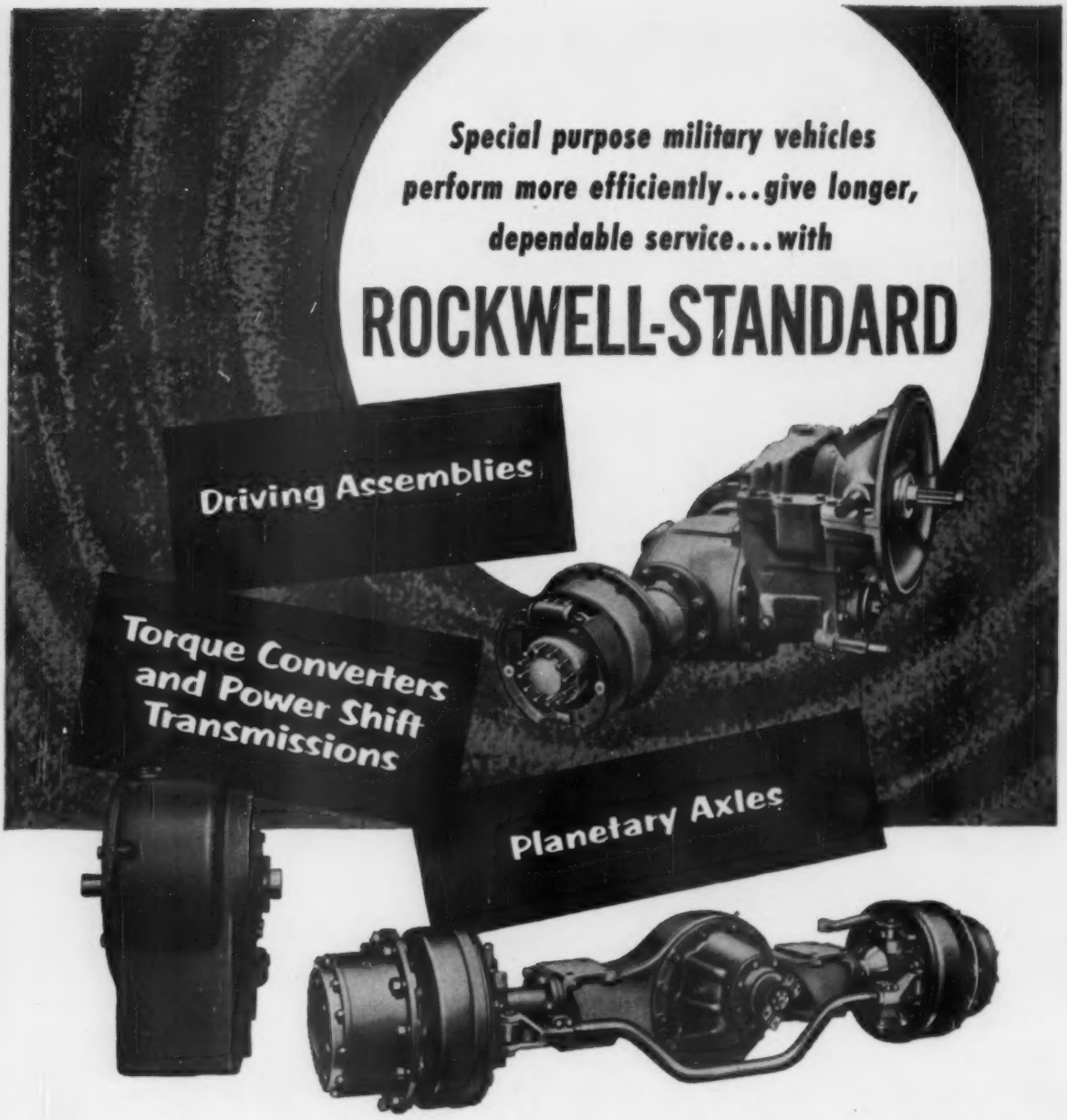

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the third interval. Converted pulses from the transistor mixer are amplified in a compression type logarithmic IF amplifier and after second detection again amplified by a narrow band video amplifier and are fed to a video mixer and finally to the telemetry section.

Payload Description

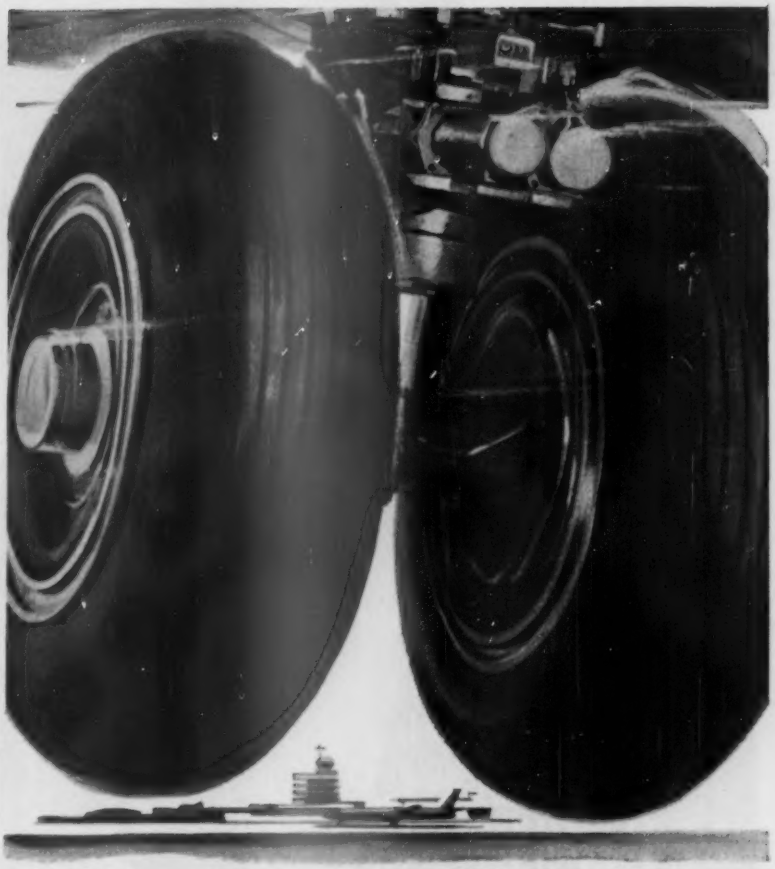
The payload will consist of two truncated cones, about 40 in. base diameter, joined by an approximately 6-in. cylindrical section. Its total length is not to exceed 36.5 in. Dipole antennas, about 32.8 ft. long, arranged in orthogonal planes, and a vertical antenna about 40 in. long—to be paid out after separation from the third state—will protrude from the payload.

A central canister in the payload will consist of a stack of 10 to 12 circular glass-epoxy circuit boards which contain the telemetry circuits, the command receiver and the radio sounder.

The upper platform acts as the base for the vertical stub antenna and two dipole elements of the sounder; vertical structure members support the remaining dipole elements.

The antennas are erected after final separation.

Weight distribution is expected to be as follows: tracing beacon—25 lb.; electronics canister—15 lb.; supporting structure—35 lb.; batteries 75 lb.; total—150 lb. Any space savings obtained in design will be applied toward extra batteries.



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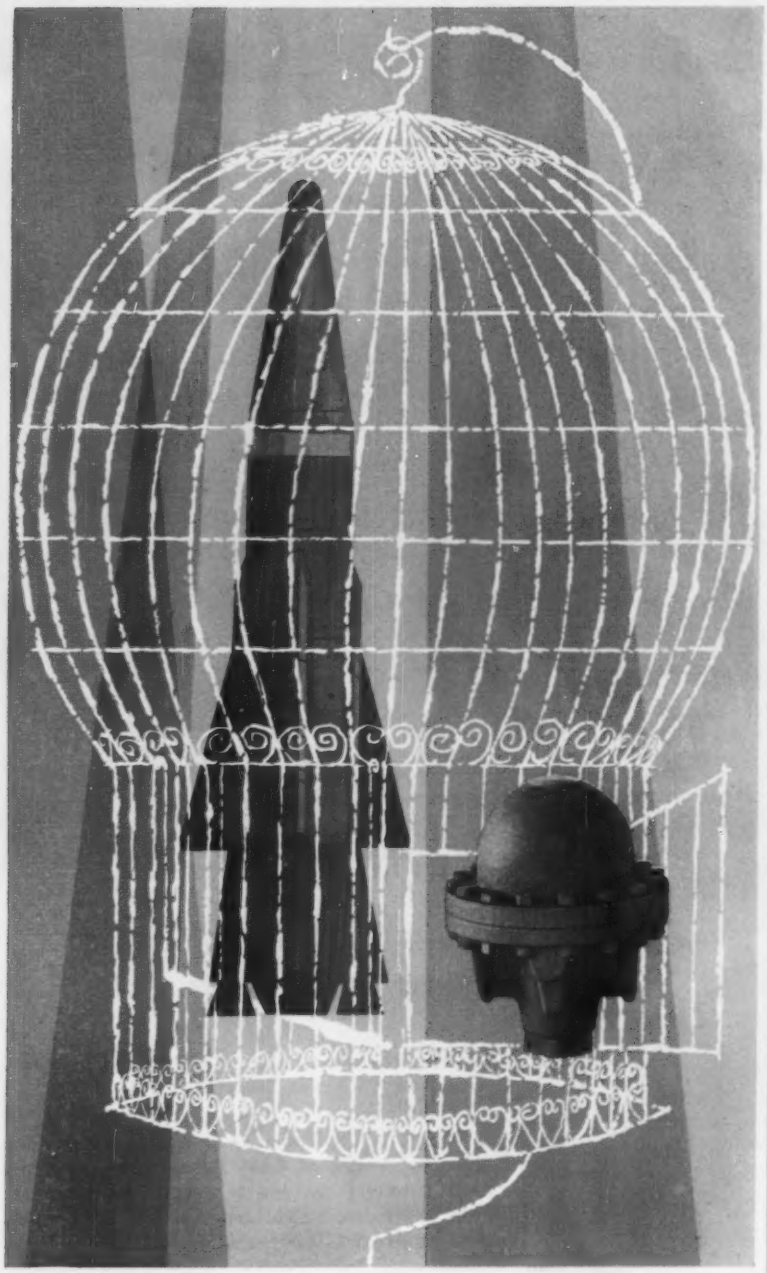

care and feeding of the bird

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FILTER CENTER

▶ **Transistor Sales Continue Climb**—Semiconductors manufacturers sold slightly more than 12 million transistors in March, nearly twice the 6.3 million sold in March 1959. March sales totaled $28.7 million, only 16% above the dollar value of March 1959 transistor sales, reflecting recent price cutting by transistor producers. Unit sales for first three months of year: 31.1 million.

▶ **Electrostatic Gyros**—Development of extremely low random drift rate gyros employing electrostatic suspension is now being supported at Minneapolis-Honeywell by Air Force and Navy contracts totaling several million dollars. Military backing of this work has released company funds for research and development of cryogenic gyroscopes which the company feels are one step beyond electrostatic gyros.

▶ **Marrying Cryogenic Techniques**—Scientists at Bell Telephone Laboratories are studying the feasibility of a superconductive parametric amplifier. Parametric amplifiers, cooled to cryogenic temperatures, have better noise figures because of reduced thermal noise. Once liquid helium is employed to cool the device it could be used simultaneously for another purpose. This would involve use of a superconductive material for the cavity which contains the diode—heart of the paramp. Lower pump power would then be necessary for amplification because of high Qs possible with a superconductive cavity.

▶ **Signed on the Dotted Line**—Major contract awards recently announced:

• **General Instrument Corp.** will produce 97 infrared cloud-height measuring systems designed to report continually and automatically cloud ceilings up to 5,000 ft. over airports and air bases under a $457,150 contract from the Rome Air Materiel Area.

• **Datalab Division** of Consolidated Electrodynamics Corp., Pasadena, Calif., will study ways and means of increasing the percentage of useful data telemetered from satellites and space vehicles during extended flights. Work is supported by $73,420 award from Wright Air Development Division.

• **Electronics and Defense Products Division** of the Wurlitzer Co., North Tonawanda, N. Y., will produce 38,700 multi-purpose electronic bomb fuzes for U. S. Army Ordnance New York District over the next nine months under a $1,741,500 award.

• **Kaiser Electronics, Inc.**, Union, N. J., will design and produce electronic power supply systems for the FAA.

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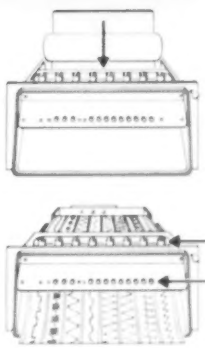
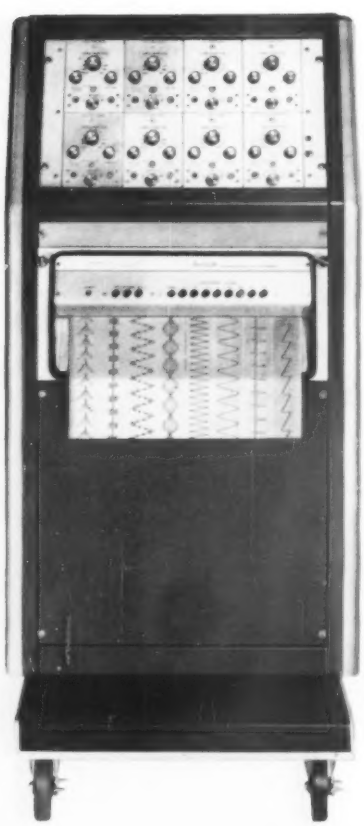
for direct writing recording systems no one is as qualified as Brush





Why? Simply because Brush recording systems such as this 6-8 channel unit incorporate all of the known refinements in the art of recording by direct writing. No comparable system in existence today is as compact . . . as simplified . . . as reliable . . . as versatile. Note slide-mounted oscillograph and interchangeable "plug-in" signal conditioners that provide four vital functions in addition to amplification: high input impedance, zero suppression, attenuation and calibration.

Instantaneous rectilinear presentation gives clear, uniform and reproducible traces for precise readout of telemetry, computer, ground control and other data gathering operations. Further, this functionally designed system has a "pull-out" horizontal writing table for convenient annotation and reading . . . without turning off the recorder! Check these and many other advanced features for yourself and you'll see why *no one* is as qualified as Brush. Call, write or wire for complete details.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

NEW AVIONIC PRODUCTS

Components & Devices

• **Semiconductor pnpn switches,** called Transwitch, are now available in smaller packages and in earlier TO-5 case at voltage ratings up to 200 v. Transwitch is a bistable silicon device which can be turned off by a gate current. Units now available in TO-5 case at 30, 60, 100 and 200 v. ratings are TSW-30, 60, 100 and 200, respectively; in TO-18 case in the same four voltage ratings as larger TO-5 case are TSW-31, 61, 101 and 201. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass.

• **Visual approach aid** for business and private airports consists of six or more xenon-gas type electronic flashing lights in weatherproof housings with accompanying power packs and a timing mechanism. Spaced 129 ft. apart just

beyond and in line with a landing strip, the lights flash in sequence, creating the illusion of a moving arrow, pointing to the center of the runway. The flashes are visible over 20 mi. from a 2,000-ft. altitude. Electronic Lights, Inc., 1713 N. Ashland Ave., Chicago, Ill.

• **Transmitting antennas** for outdoor service on microwave antenna test ranges give maximum frequency coverage for each reflector with a minimum number of interchangeable feeds. Reflectors are spun aluminum parabolids with 1 to 10 ft. diameters and each reflector assembly includes feed mount with rapid feed interchange capability. Features of the new antennas are high gain, optimum side lobe-bandwidth characteristics, and optimum imped-

NEW FAN & FLOW CONTROL
Guaranteed 2,000 Hour Life, Flow is Independent of Outside Control
Task's design approach to customer requirements for aircraft radio compartment cooling has resulted in the development of this lightweight, high efficiency integral fan and flow control unit. Guaranteed for 2,000 hours life, the unit has passed rigid qualification required for commercial aircraft use. Fan motor is equipped with overheat protector and specially designed flow control discharges air from sea level to 30,000 ft. at 15 to 22 lbs. per minute.
Other exclusive features include: stationary fins on forward end bell for heat dissipation as motor rotates blower, and inclusion of an insulated aluminum probe to sense stator lamination temperature.
Weight: 5.2 lbs. Length: 9.5". Diam. 4.8". 4 pole, 200 V., 400 cps, 3 phase AC motor consumes 2.0 amp full-load, (9.0 amps with rotor locked).
REAR VIEW
Flow of discharged air is controlled by varying butterfly position.
Designed for use in the Atlas missile telemetry system. Weight: 1.5 lbs. 200V, 400 cps, 3 phase, AC. Produces 300 CFM at 0.5 in. of water.
In use as aircraft galley exhaust fan on Lufthansa Airlines. Weight: 1.4 lbs. 200 V, 400 cps, 3 phase, AC. Produces 150 CFM at 0.5 in. of water.
For further information on any unit described, or a no obligation review of your specific requirements phone PRospect 4-3100 or write:
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TASK CORPORATION
1909 E. VERMONT AVENUE, ANAHEIM, CALIFORNIA, PRospect 4-3100

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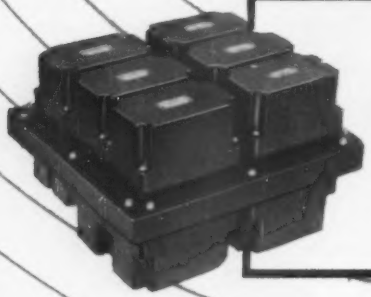
SUPERIOR ACCURACY

in heat control systems

Extremely compact proportional and switch-type heat control systems from Magnetic Controls Company are accurate to within .01° F. and are available in models to handle a wide variety of output requirements. Typical applications include gyros, inertial platforms, jet aircraft windshield anti-icing and anti-fogging systems, aircraft cabins, and guidance shipping containers.

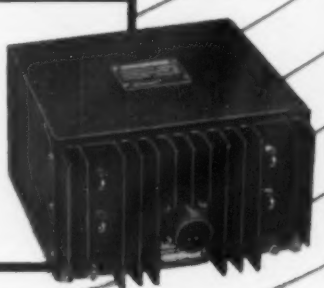


in voltage monitoring systems

The thousands of critical voltages in computers — which must be monitored in order to track missiles accurately — led to the voltage monitoring systems developed by Magnetic Controls Company. Use of highly sensitive, rugged magnetic amplifiers in these systems assures super-accurate response from varying load currents and line voltages.

in static inverters

Ultra-reliable static power inverters from Magnetic Controls Company utilize tuning-fork oscillators for precision frequency, plus transistor, silicon controlled rectifier and magnetic amplifier circuitry for stable power output. These super-accurate inverters are well suited for use in missiles, missile and rocket checkout systems, automation setups, jet ignition systems, gyro-wheel power supplies, computers and many other spaceborne, airborne and ground support applications.



If you have applications requiring super-accurate heat regulating, voltage monitoring or power inverting systems, it will pay you to contact Magnetic Controls Company. Write or phone today for complete information.

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Heat Control Systems • Static Inverters • Voltage Monitoring Systems

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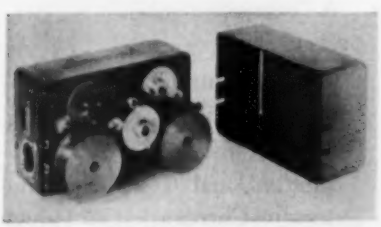
.nce-bandwidth characteristics, according to Scientific-Atlanta, Inc., 2162 Piedmont Rd., N. E., Atlanta 9, Ga.

• **Magnetic tape recorder reproducer,** PR-2300, capable of being transported in its carrying case or mounted on standard racks, can record or play back bidirectionally up to 14 channels of direct record or wide band FM analog data. Unit records and reproduces at speeds of 60, 30, 15, 7½, 3¾ and 1⅞ ips. Speeds are changed in pairs by changing drive belts and are selected within each pair by push button control. Tape speed is held constant to within ¼%. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif.

• **Transistor,** silicon mesa Type 2N752, is useful for small signal operations up to 200 mc. where high reliability and resistance to severe environmental conditions are required. In many instances, this transistor may replace 2N702, 2N706, 2N696, 2N333, 2N337, 2N117 and 903 transistors. Device dissipates 300 mw. in free air, minimum collector-to-emitter voltage of 45 v. and emitter-to-base voltage of 8 v. Leakage current is 5 microamps at 150C and collector-to-base capacitance is 5 picofarads. National Semiconductor Corp., Danbury, Conn.



• **Punched tape programmer,** Model TP-860, an 8-channel, time base unit for automatic programing uses standard teletype punched tape. Model provides precision time base programing with 20 min. of programing at 1 ips. tape

PIONEERING IS OUR BUSINESS

Measuring only 10" x 16" x 7" and weighing only 18 lbs. full, the Bendix Pressure Suit Ventilator can be carried conveniently by airmen through all pre-flight procedures.

Bendix FULL-PRESSURE-SUIT VENTILATOR REDUCES PRE-FLIGHT FATIGUE, DISCOMFORT

Wearing tight, full-pressure flying suits during briefings and other pre-flight ground activities can cause airmen enough discomfort to create fatigue, tension—possibly even physical disability. The Bendix Full-Pressure-Suit Ventilator (Type GU-250) was designed to reduce these conditions and provide the comfort required to maintain a high level of efficiency.

Its sturdy, compact aluminum case—containing the liquid gas converter and all components—provides a supply of dry cooled air for a minimum of one hour of normal activity. Usable with any garment needing ventilation. Convenient carrying handle—or optional shoulder strap. The unit requires no battery, electric power or ice. Write for full details.

OTHER SPECIFICATIONS:

Converter capacity	2½ liters.
Operating pressure	70 psig.
Fill point	Standard military filler valve to mate with AF55D3795 Filler Nozzle.
Outlet	Outlet to fit Pressure Suit Ventilator Hose.
Ventilator material	Stainless steel converter bottle; standard converter components.
Flow capacity	Venturi nozzle flow: 45 liters per minute maximum. Total delivery: 250 liters per minute of air against 12" of water back pressure.

Pioneer-Central Division
HICKORY GROVE ROAD
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West Coast Sales and Service, Burbank, Calif.
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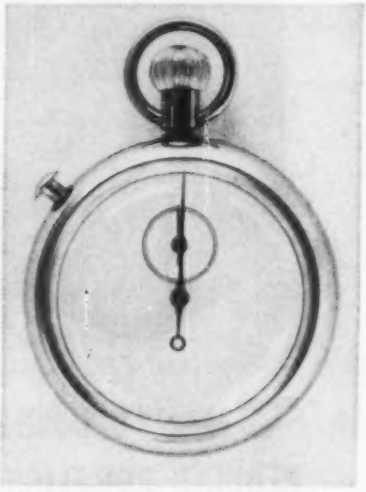
THE Bendix CORPORATION

ITT is 'creating' a one-second minute for SAC



Time, always of the essence, is even more so in the Strategic Air Command. A second's fraction, in SAC's reaction time, could mean Survival.

To have this fractional "edge" in time, SAC's commander *must* have all relevant data right in front of him *instantaneously*. Hence the new electronic complex, now under development, designated 465-L. When completed, this SAC Control System will eliminate the human steps (delays) between what is happening in hundreds of constantly shifting situations around the world . . . and SAC's *knowledge* of what is happening.

The SACCSystem (465-L) is therefore a complex of electronics projects of which data acquisition and processing are only a part. It is an undertaking in *total* Command and Control, world-wide.

Accordingly, the prime contract to accomplish this complete communications system was awarded to ITT, the world-wide communications and electronics enterprise. ITT designated its associate, International Electric Corporation, system manager. ITT companies, muscled by 7200 idea-exchangers in 24 countries, have a proven track record when it comes to the vital business of getting information from any field, or combination of fields, instantaneously to a headquarters display board. When it comes, in a word, to Communications.

SACCS has three elements: 1) Data Transmission, which includes a Remote Communications Complex — through which data from SAC bases and missile sites are high-speeded, by digital data links, to Traffic Control Centers whose central switching systems route data to display or to 2) Data Processing Central—which provides high-speed computation and storage and is capable of priority-interrupt and simultaneous input-output operation. And 3) Data Display—where totality of SACCS' information can be specifically discovered and viewed by SAC staff.

The transcendent urgency is to process any datum receivable from any site *as fast as humanly possible*, giving SAC a greatly improved capability resulting in decision based on more reliable data, furnished in a more refined form.

A one-second minute is obviously a metaphor. But ITT, as much as is humanly and machinely possible, is endeavoring to make it a fact.

International Telephone and Telegraph Corporation, 67 Broad Street, New York City 4, New York.

ITT

ITT, with its 136,000 employees, is the largest American owned world-wide Electronics and Communications enterprise.

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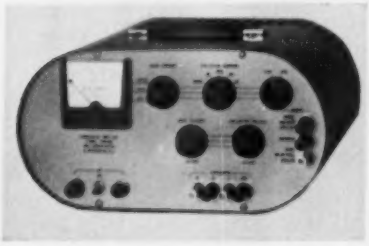
speed and has forward drive and automatic rewind with separate motors for each operation. Completely self-contained, the unit measures 5 x 8 x 6 in. including space for storage reels capable of holding 100 ft. of tape. With six week delivery price is $875, F.O.B. company, Anaheim Electronics Division, Electronic Engineering Co. of California, 1601 East Chestnut Ave., Santa Ana, Calif.

Test Equipment

• **Semiconductor device tester,** Model TTS-100, can evaluate and inspect transistors, Zener diodes, rectifiers and tunnel diodes. Tester will evaluate transistors for breakdown voltage, gain over the complete dynamic range, voltage and current saturation characteristics and leakage currents at voltages up to 80 v.; Zener diodes for breakdown

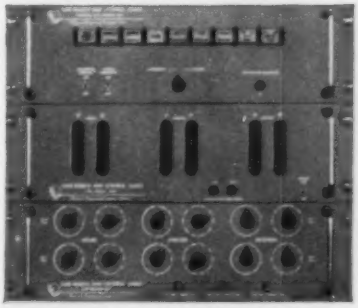


voltage, dynamic impedance at any current within the range of the diode, drift against temperature or current; rectifiers for leakage up to 80 v. and forward current characteristics of up to 1 amp; tunnel diodes for tunneling and valley currents and forward voltage. Units are priced at $295 F.O.B. the company, PRL Corp., P. O. Box 215, East Brunswick, N. J.

• **Accelerometer,** Model LA22-0401-1, a three axes unit with potentiometer output that weighs ¼ lb., provides information on linear acceleration along three axes. Unit measures 2¼ in. diameter, 2 in. long and can withstand operating temperatures between −65 and 180F, 100% relative humidity, unlimited altitude, 75g shock for 6 milliseconds on any axis without damage. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif.

HANDS OFF

NO MANUAL SWITCHING FOR SPEED CHANGES WITH EECO'S NEW TIME-CODED MAGNETIC TAPE SEARCH AND CONTROL SYSTEM



Responsible for flight test instrumentation? Quick-look data readout? Check out this addition to the distinguished EECo line of timing system equipment. You'll find no other gives you all of the ZA-821's important benefits:

NO MANUAL SWITCHING or plug-changing is needed to compensate for speed changes.

DATA REFERENCED BY TIME CODE, so correct locating never depends on tape speed. Locates data interval between two time addresses.

CONTINUOUS DECIMAL DISPLAY OF TIME CODE, so user always knows exactly where he is on the tape.

SPEED WITH FLEXIBILITY. With typical tape transport, ZA-821 searches 1200 feet of tape in 90 seconds. Permits search-to-recording speed ratios up to 64 to 1.

FULLY AUTOMATIC. Choice of automatic or manual search. Permits automatic recycling of located data.

COMPACT. All solid-state. Entire ZA-821 unit including power supplies mounts in only 15¾" of rack space.

COMPATIBLE. Can be used with most continuous-motion tape transports including Ampex FR 100, FR 100A, FR 100B, FR600; Honeywell M-3170, M-3171, M-3172; CEC 5-752; Mincom C-100. Uses 24-bit BCD Time code supplied by EECo ZA-801 Time Code Generator. Can be modified for use with any time code.

ECONOMICAL. High utility. Beats in-house fabrication. Plug-in circuits keep maintenance cost down. Only $11,400.

For data sheet ZA-821 write:

Electronic Engineering Company *of California*

1601 East Chestnut Ave., Santa Ana, Calif. Phone Kimberly 7-5501. TWX: S ANA 5263

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AERIAL REFUELING TANKERS

STRATEGIC OR TACTICAL

Now, in a matter of minutes, Air Force tankers can be converted from a strategic to a tactical role.

This kit is designed for field conversions from the boom system to the probe and drogue system—successfully tested and now operational with the Air Force.

The kit containing all components, spares and test equipment is designed for stowage aboard the tanker aircraft. Thus equipped, Air Force tankers can refuel most aircraft anywhere in the world.

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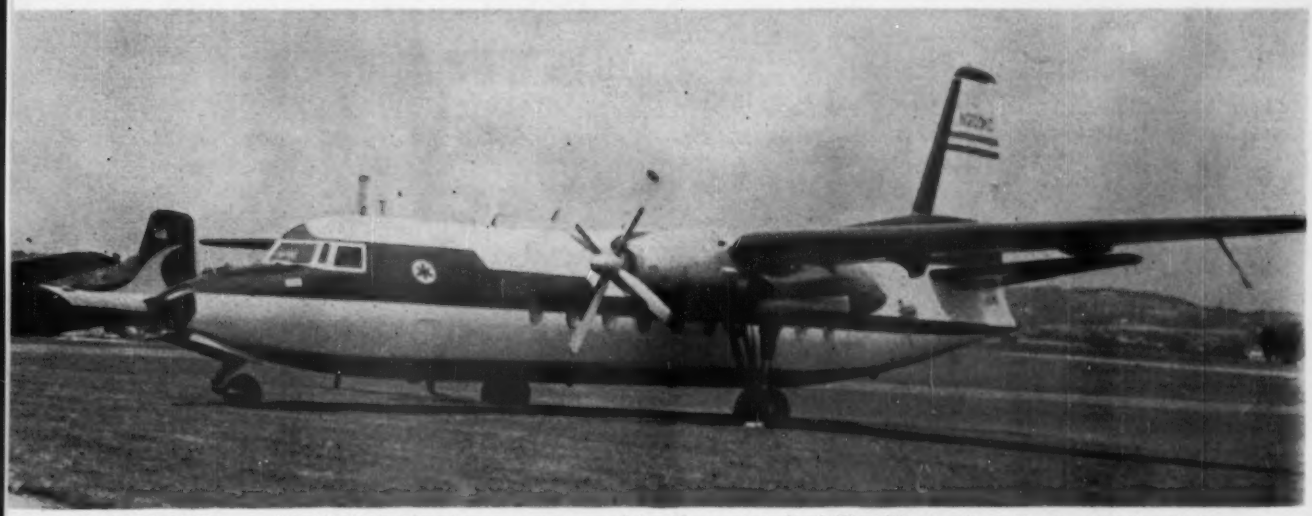
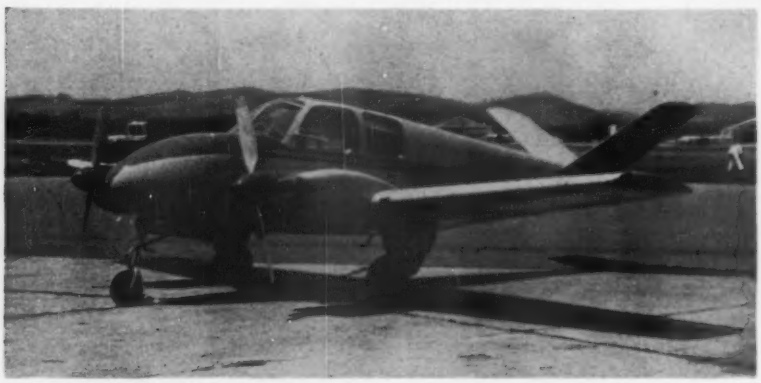
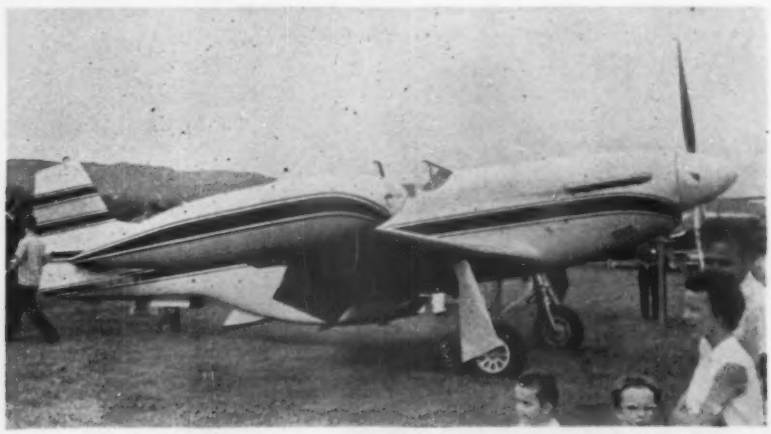


FAIRCHILD F-27 owned by Kimberly-Clark Corp. received award for "best exterior" of Class VI aircraft at Reading Aviation Services 11th National Maintenance and Operations Meeting. Kimberly-Clark airplane was one of four F-27s on display at the show.

Turbine Impact Marks Reading Air Show



OAKLAND AIRMOTIVE'S Super-V, a Bonanza conversion with two Lycoming O-360 engines of 170 hp. each. Empty weight is 1,900 lb.; gross weight is 3,400 lb.



EXECUTIVE MUSTANG, modified by Trans-Florida Aviation, Inc. Two-place F-51D has an empty weight of 7,100 lb.; gross of 10,500 lb. Maximum speed, 30,000 ft., is 457 mph.

By Robert Stanfield

Reading, Pa.—Increasing turnout of turbine-powered and modified executive aircraft marked industry representation at Reading Aviation Service's 11th National Maintenance and Operations Meeting. About 500 aircraft were flown.

About 2,000 members of the industry, plus general sightseers, attended 8 a.m. to 4 p.m. sessions of the two-day show at General Spaatz Field, Reading's municipal airport, where Reading Aviation Service, Inc., the sponsor, had allocated 91 display booths to 56 industry representatives.

All categories of aircraft were flown in by manufacturers and owners, to be supplemented by various equipment exhibits set up in the booths. In addition to single-engine and light-twin executive aircraft, a modern "heavy" business fleet, estimated at a total value of $20 million, included Lockheed's JetStar, four Fairchild F-27s, three Grumman Gulfstreams, a Howard Model 500 (pressurized Lodestar refinement), an Alleghany Convair 540, and a Martin 404.

Modifications

Among modified aircraft were McCann-Erickson's On Mark A-26; the Trans-Florida Aviation executive two-place F-51D Model (owned by Bank of Mid-America Corp.); Oakland Airmotive's Super-V—a Beechcraft Bonanza fitted with two Lycoming O-360 engines of 170 hp. each; Conrad International Corp.'s Conrad 9800—a

Beech G18S with fuel injection and three-bladed propellers—and an executive B-25J owned by Cliff Boyer.

In the "antique" class were a 1936 two-cylinder, 37-hp. Aeronca C-3 "flying bathtub," a Beech staggerwing D-17 of 1940 vintage, owned by Atlantic Aviation, and a 1939 Spartan 7W Executive. Two sailplanes were on display: Schweizer's SGU 2-22C two-place high-wing trainer, and SGS 1-26 single-place medium-performance aircraft.

Newest airplane displayed, and flown, was Aero Design and Engineering Co.'s Aero Commander 500A, first of a new series (AW May 9, p. 103), with airfoil-shaped engine nacelles with exhaust ports on top to reduce cabin noise. Powerplants are two Continental IO-470-M fuel injection engines delivering 260 hp. at 2,625 rpm.

Intermittent rain and low ceilings marred most demonstration flights planned for Saturday, concluding day of the show.

The meet also marked the introduction by the Link Division of General Precision, Inc., of ground trainers designed specifically for general aviation. Link trainers are aimed specifically at light aircraft pilots who need instruction or proficiency brush-up in IFR flight and radio procedures.

Separate Units

Model 60 series comprises three separate units: the 60E electronic trainer, the 60M mechanical trainer and the 60R radio aids unit. Prices range from less than $1,900 for the mechanical trainer to under $19,900 for the combined electronic trainer and radio aids unit.

The 60E simulates aircraft performance between sea level and 8,800 ft. at speeds of from 85 mph. to 220 mph. Panel includes an airspeed indicator, altimeter, gyro horizon, directional gyro, vertical speed indicator, turn and bank, and clock. Side-by-side seating accommodates instructor or extra student.

The 60R radio aids unit allows practice of radio navigation and instrument approaches, when used with either trainer. Cross-country flight may be made within a 4,900 sq. mi. area. Unit provides 19 individual radio aids facilities, including VOR, low frequency range or beacon, ILS and marker beacon.

The 60M low-priced mechanical version of the trainer has the same instruments as the electronic trainer but is designed primarily for use with the radio aids unit for cross-country navigation training. Instruments give static flight conditions such as climb, turns and level flight at varying speeds. It is recommended primarily for pilots familiar with instrument flight, for refresher work.

Discussions held during the meet

CONRAD 9800 modification includes Simmonds SU-580 series of fuel injectors and three-bladed propellers. Gross weight at takeoff is 9,800 lb. Single-engine climb is 300 fpm.

LINK'S new Model 60E electronic trainer simulates lightplane performance between sea level and 8,800 ft. at speeds of 85 to 220 mph. Also shown is Model 60R radio aids unit which, when used with trainer, allows navigation practice and instrument approaches.

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included a flight instructors' round table, sponsored by the National Pilots Assn.; techniques of airway and weather flying, with Capt. Robert Buck of Trans World Airlines; radar operation and meteorology, by Howard R. Hoffman of United Air Lines' radar training school; new concepts of cockpit instrumentation, with Al Mayo, Douglas Aircraft Co.; impact of turbines on general aviation by R. W. Cary, Allison Division, and forums on engine operation and maintenance, and instrument flying.

Horizon Evaluation

Flight evaluation of the Coffing 3-D Horizon, of which about 200 are now flying, was made by this AVIATION WEEK pilot during the show. Manufactured by Coffing Industries, Inc., of Covington, Ind., the gyro horizon would be useful to the beginner or VFR pilot who could inadvertently fly into IFR conditions or low visibility areas.

The instrument lets a pilot "see himself fly" through a three-dimensional arrangement of a miniature airplane and a converging "section line" grid pattern differentiating horizon and ground. By observing the position of the miniature airplane inside the instrument, a pilot can detect and correct his aircraft's attitude.

Instrument aid, approved by the Federal Aviation Agency for all Class II aircraft, was checked in a Piper Comanche 180, along with pilot Jimmie Selsor of Coffing Industries. The 3-D indicator, a suction driven gyro, was mounted just left of center on the Comanche's instrument panel, within a "bubble" of one-eighth inch ultraviolet transmitting plastic which permits passage of any type instrument lighting.

Tumbling Limits

On scale at the bottom of the instrument are 30-deg. increments to show roll, along with an arrow-type roll indicator. Tumbling limits are 97 deg. roll, 82 deg. pitch. Grid lines are white on black. Trailing edges of the miniature airplane are marked to glow under all standard cockpit lighting.

The miniature airplane within the plastic bubble held the same attitude as the Comanche while taxiing and through all phases of flight. It can be adjusted to fit the eye level of the pilot. With AVIATION WEEK's pilot under the hood, the Comanche was put into unusual conditions—including power-on stall, climbing turns, and left-right spirals—all easily "read" by the attitude of the miniature aircraft, and all easily and quickly compensated.

During return the 3-D held the correct attitude through the traffic pattern and approach. As a student safety fac-

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Heat Problem?

DUMONT CAN HELP

High-temperature insulation for missile components is a major space-age problem... and a Dumont specialty. Polaris and Minuteman already testify to the experienced skills of Dumont in high-pressure molding of reinforced plastics. Characteristic of Dumont's ability to meet new challenges with new solutions is the development of the first tactical lightweight plastic exhaust nozzle to combine structural and insulating components into a single assembly. The future of missile flight is dependent upon thermal insulating requirements of rocket motors, nose cones, re-entry vehicles. Dumont's advanced techniques of high-pressure compression and autoclave molding, supported by process and materials development, are already prepared to meet those requirements.

Dumont's experience and technology in the field of high-temperature insulation and sandwich structures are available through its technical service staff. Learn how Dumont's facilities and abilities can help you find insulation answers. Write today for Brochure D.

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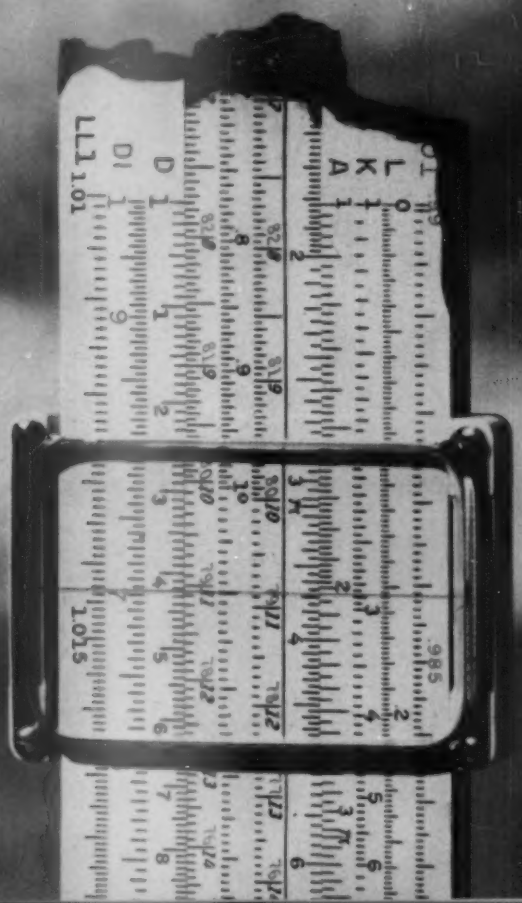

KC-97s on the flight line at Temco's Overhaul & Aerosystems Division installation at Greenville, Texas.

With its mixed force of penetration aids, SAC is ready to deliver a multiple punch on instant's notice. To maintain this always alert posture and secure its strike capability, SAC must keep a sizable number of bombers in the air at all times. In turn, these bombers must be refueled by the Command's tanker fleet. As one of SAC's major maintenance depots for these tankers, Temco's Overhaul & Aerosystems Division has a vital part in keeping SAC in the air. In one month alone, Temco set a production record of complete IRAN operations on 27 KC-97s.

IN THE AIR

Volume depot level maintenance is one phase of a complete service provided SAC and other Air Force organizations. Temco Overhaul & Aerosystems is participating in the AN/USD-7 program as a team member responsible for systems integration, installation and flight testing. Design, development and installation of electronics weapons systems for special mission aircraft is a growing capability. In this field of aerospace vehicles, both as prime and subcontractor, Temco has built a reputation as a good producer, turning out quality products on time and with economy.

TEMCO OVERHAUL & AEROSYSTEMS

A Division of TEMCO AIRCRAFT CORPORATION • *P.O. Box 1056 • Greenville, Texas*

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- Backcourse Glide Path
- Multiple Runway
- IFF Display
- Surveillance Radar
- Precision Approach
- Tactical or Fixed Radar

In
- Netherlands
- Norway
- Aleutians
- Yugoslavia
- Japan
- Korea
- South Pole
- Argentina
- Australia
- Austria
- Canada
- Denmark
- Ireland
- Finland
- France
- Germany
- Israel
- Italy
- North Africa
- New Zealand
- United States

Circle Number 262 on Reader-Service Card

Reading Aviation Services Awards

11th National Maintenance and Operations Meeting

CLASS	TYPE AIRCRAFT	OWNER
Antiques:		
Oldest	C-3 Aeronca	Fred Shallcross
Best Restored	C-3 Aeronca	Fred Shallcross
Single-Engine:		
Best Exterior	Cessna 170B	Rebco Printing Co.
Best Interior	Bonanza K35	Pristow's Motor Sales
Best Equipped	Bonanza K35	C. B. Ripley
Best of Class	Bonanza K35	Pristow's Motor Sales
Class 1-A (ex-military)	F-51D Model 2000	Bank of Mid-America Corp.
Class II:		
Best Exterior	Beech B95 Travel Air	Frank Reese
Best Interior	Cessna 310D	Don Shepard Co.
Best Equipped	Beech B95 Travel Air	Richard D. Clemson
Best of Class	Cessna 310D	Don Shepard Co.
Class III:		
Best Exterior	Aero Commander 560E	Pa. Glass Sand Co.
Best Interior	Aero Commander 560E	Pa. Glass Sand Co.
Best Equipped	Aero Commander 560E	Pa. Glass Sand Co.
Best of Class	Aero Commander 560E	Pa. Glass Sand Co.
Class IV:		
Best Exterior	Beech G45 (Conrad Conversion)	Brockway Glass Co.
Best Interior	Beech G45	Manor Aviation, Inc.
Best Equipped	Beech Super E18S	Rust Engineering
Best of Class	Beech Super E18S	Rust Engineering
Class V:		
Best Exterior	Lockheed Gulfstar (Lodestar conversion)	Gulf Oil Co.
Best Interior	Lockheed Gulfstar	Gulf Oil Co.
Best Equipped	Lockheed Gulfstar	Gulf Oil Co.
Best of Class	Lockheed Gulfstar	Gulf Oil Co.
Class VI:		
Best Exterior	Fairchild F-27	Kimberly-Clark
Best Interior	Convair 440	Coca Cola Co.
Best Equipped	Grumman Gulfstream	Upjohn Co.
1960 Flagship of U.S. Industrial Fleet	Grumman Gulfstream	National Distillers

tor, it should make the 180-deg. turn easy. Cost of the 3-D, a standard gyro horizon instrument modified with miniature airplane configuration and indicia, is $320, with exchange of the old instrument. Cost without exchange is $337.50. Installation time runs from 30 min. to 1 hr.

Static Displays

Key features of some of the modified aircraft displayed at the show include:

• **Executive Mustang.** Modified by Trans-Florida Aviation, Inc., Sarasota, Fla., the two-place F-51D Model 2000 displayed was sold to the Bank of Mid-American Corp., Oklahoma City, for just under $50,000. Normal cruise, between 15-25,000 ft., is specified at 360 mph. TAS. Maximum speed at 30,000 ft. is 457 mph. TAS. Pattern speed is 150 mph. indicated; stall speed in landing configuration is 87 mph.

Mustang's normal cruise fuel mileage is listed as 5.2 mi. per gal. Main wing-tanks fuel totals 184 gal.; main and tip tanks total 376 gal. Empty weight is 7,100 lb.; gross weight is 10,500 lb. Service ceiling is 40,000 ft.

• **Conrad 9800.** Modified by Conrad International Corp., Cincinnati 26, Ohio, the Twin Beech (a refined Super G18S or D18S) includes a new exhaust system, reworked engine cowling, Simmonds SU-580 series of fuel injectors, and Hartzell three-bladed full-feathering propellers. Other modifications include a one-piece wrap-around windshield, new wheel well doors, change of horizontal stabilizer angle of incidence (from minus 2 deg. to minus one/half deg.), stall strips to reduce stall speed. One-foot reduction in wing span, without reducing area, was accomplished by squaring wing tips.

The 9800 is certificated at 9,800 lb. for takeoff and 9,400 lb. for landing. Single-engine climb, sea level, is specified as 300 fpm. Takeoff distance, sea level, to clear a 50-ft. obstacle, is 2,300 ft. Gear extension speed is advanced to 160 mph. Single-engine en route altitude has been increased to 7,875 ft. at 9,800 lb. gross weight; single-engine ab-

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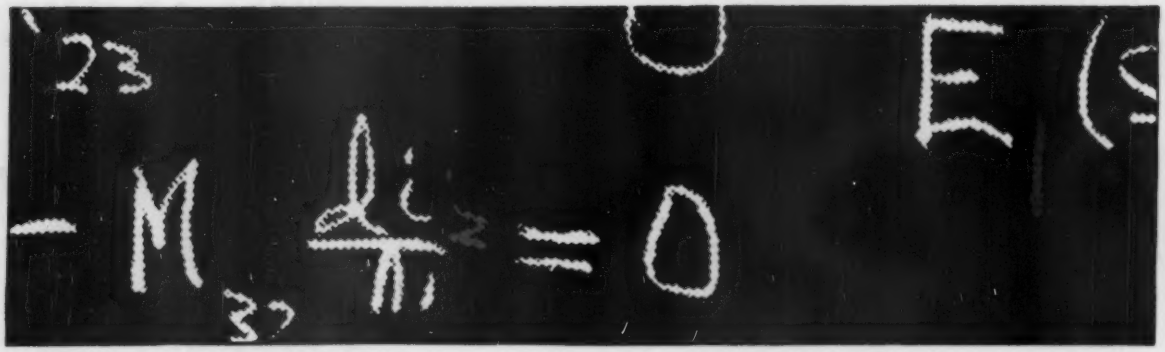
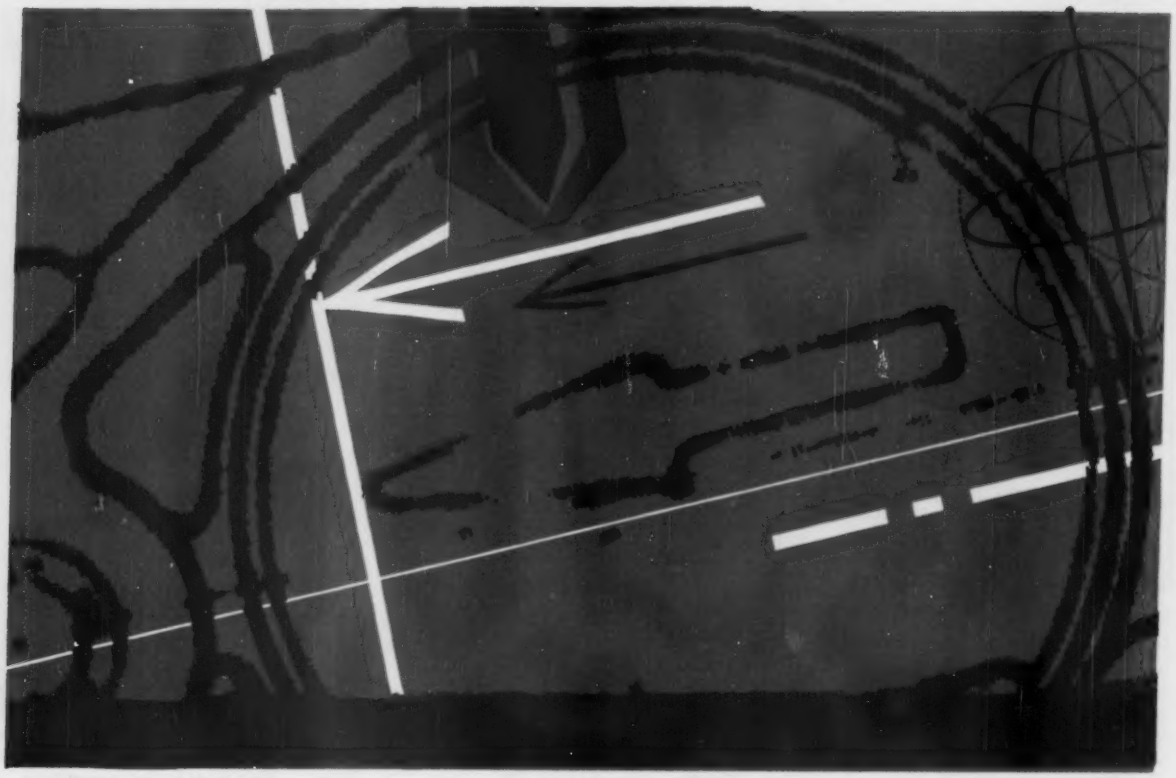


General Motors pledges

AC QUESTMANSHIP



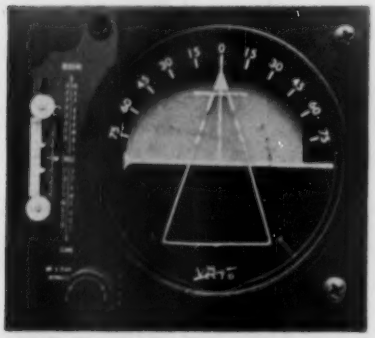
AC Seeks and Solves the Significant—AC Design and Development is moving far ahead in new technology—the result of GM's commitment to make ever larger contributions to the defense establishment. AC plans to resolve problems even more advanced than AChiever inertial guidance for Titan / This is AC QUESTMANSHIP. It's a scientific quest for the development of significant new components and systems . . . to advance AC's many projects in guidance, navigation, control and detection / Dr. James H. Bell, AC's Director of Navigation and Guidance, sees this as a "creative challenge". His group takes new concepts and designs them into producible hardware having performance, reliability and long life. He strongly supports the fact that an AC future offers scientists and engineers "a great opportunity to progress with a successful and aggressive organization" / If you have a B.S., M.S., or Ph.D. in the electronics, scientific, electrical or mechanical fields, plus related experience, you may qualify for our specially selected staff. If you are a "Seeker and Solver", write the Director of Scientific and Professional Employment, Mr. Robert Allen, Oak Creek Plant, 7929 So. Howell Ave., Milwaukee, Wisconsin.

GUIDANCE / NAVIGATION / CONTROL / DETECTION / AC SPARK PLUG *The Electronics Division of General Motors*

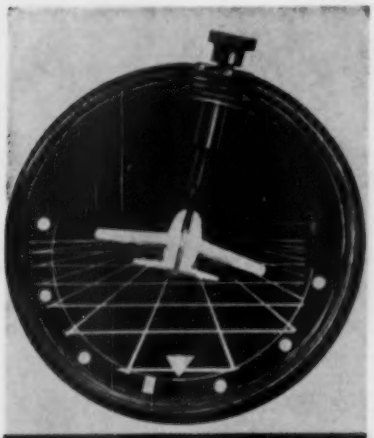
Circle Number 352 on Reader-Service Card

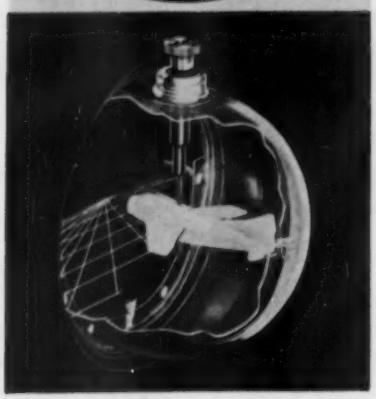
solute ceiling to 9,000 ft. Endurance is 6 hr., with 45 min. reserve.

• **Super-V.** Conversion of the single-engine Beech Bonanza into two-engine configuration, by Oakland Airmotive Co., Oakland, Calif., ranges from $22,500 for a standard version to $25,695 for one de luxe model. Cost factors run from conversion, matching paint and certification, through interior design, soundproofing, hyper wing tips, new ¼ in. thickness windows and windshield

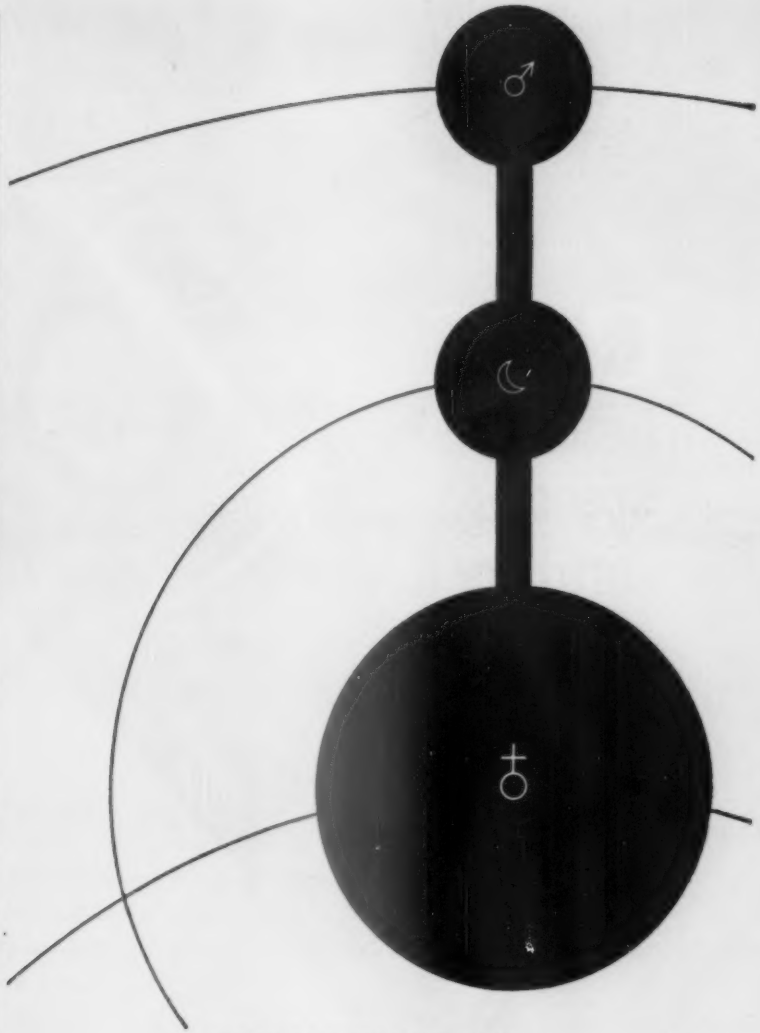


VECTO flight system reduces to one instrument speed, directional and climb angle control. Flight path computer is mounted alongside the gyro horizon.





COFFING 3-D Horizon is designed primarily for the beginning or VFR pilot who finds himself in instrument conditions, gives three-dimensional reference ease.



SYMBOLS IN THE SKY

The Moon (☾) ... Mars (♂) ... and other planets are getting closer to our doorstep (♂).
A great American team ... the huge complex of industry, science, military and civilian workers, are building the vehicles which will soon make the planets our next door neighbors.
California General ... fabricators of assemblies for rockets and missiles ... is a significant part of this team.
California General salutes this industrial and scientific complex ... and its contribution to the conquest of space ... the 20th century miracle.

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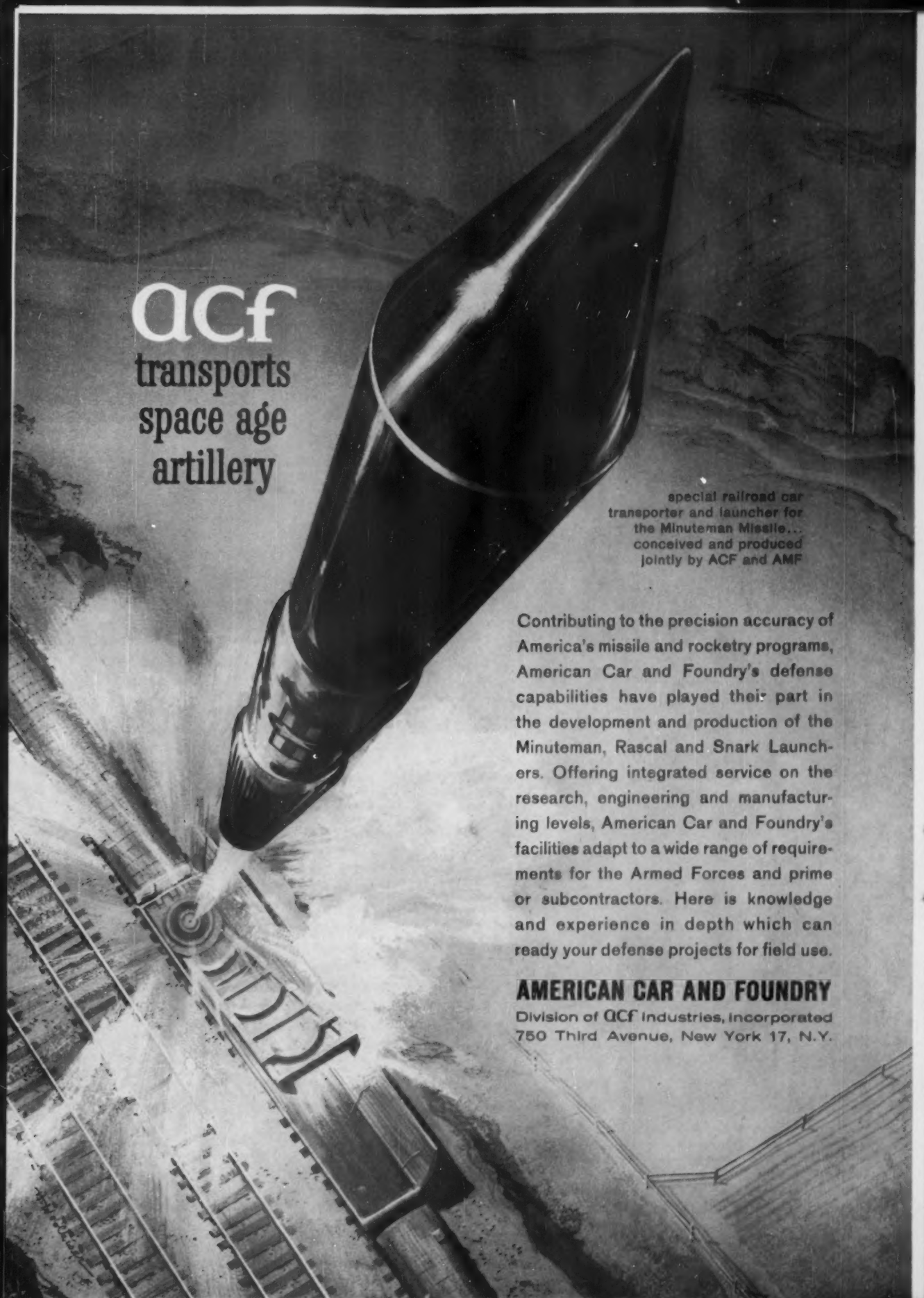

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transporter and launcher for
the Minuteman Missile...
conceived and produced
jointly by ACF and AMF

Contributing to the precision accuracy of America's missile and rocketry programs, American Car and Foundry's defense capabilities have played their part in the development and production of the Minuteman, Rascal and Snark Launchers. Offering integrated service on the research, engineering and manufacturing levels, American Car and Foundry's facilities adapt to a wide range of requirements for the Armed Forces and prime or subcontractors. Here is knowledge and experience in depth which can ready your defense projects for field use.

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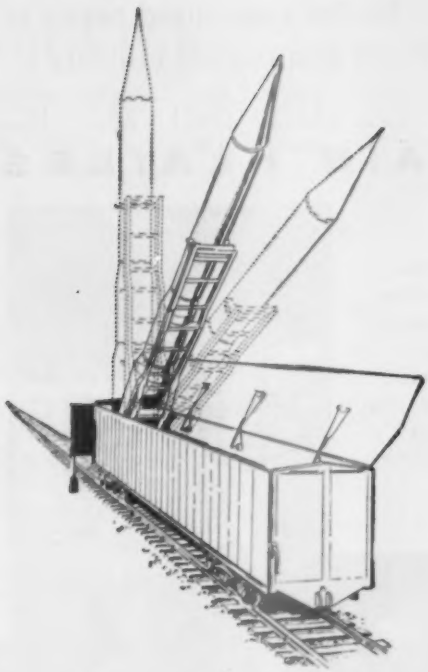

ACF's CHECK LIST FOR DEFENSE PROCUREMENT

☑ **engineering:** American Car and Foundry's engineering staff is trained to design from rough plans, develop the product to meet performance standards and create the processing equipment which will achieve the most efficient production.

☑ **manufacturing:** Five huge plants offer advanced facilities for tooling, heat treating and fabricating both ferrous and nonferrous metals and modern alloys.

☑ **research & development:** From initial drawing to prototype, through pilot or full plant production—sound, modern, workable products.

☑ **quality control:** Every phase of the manufacturing process is inspected by up-to-the-minute equipment and techniques to insure highest standards of quality and performance.

☑ **experience:** Ammunition • Armored vehicles • Propulsion system components • Ground Support equipment • Transportation equipment • Communications hardware • Research and development

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aircraft and missile industry...

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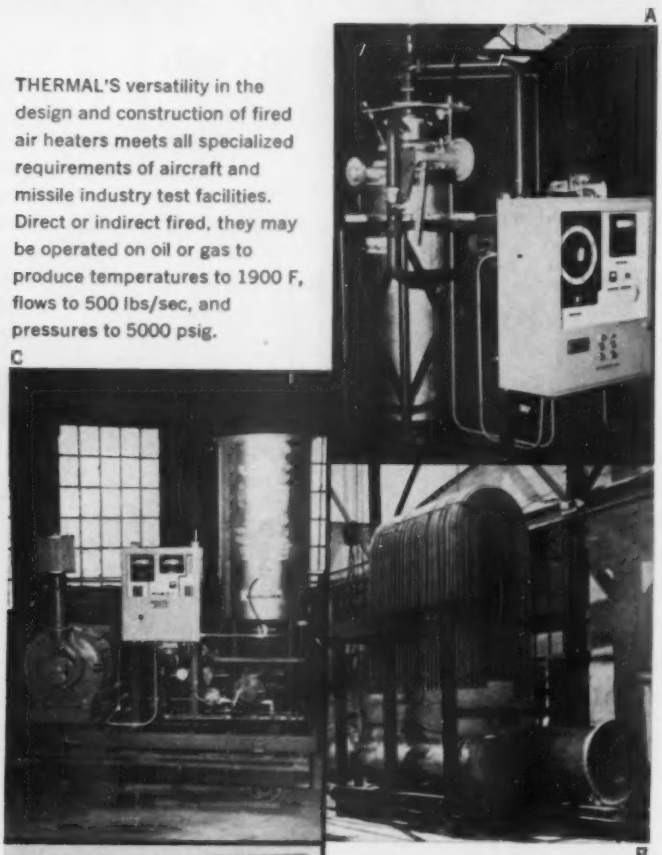
FIRED AIR HEATERS

THERMAL'S versatility in the design and construction of fired air heaters meets all specialized requirements of aircraft and missile industry test facilities. Direct or indirect fired, they may be operated on oil or gas to produce temperatures to 1900 F, flows to 500 lbs/sec, and pressures to 5000 psig.



A. Fully packaged 1,500,000 btu/hr indirect type air heater including all controls.

B. Tube bundle in fabrication (inverted) for a 150 lbs/sec, 900 F 150 psig air heater.

C. Direct fired heater for 6,000,000 btu/hr 3 psig pressure including all controls.

D. Completely "packaged" 600,000 btu/hr air heater to provide a wide range of outlet temperatures from 600 F to 1600 F for aircraft parts test work.

For further information write for Bulletin 113 (indirect fired) • 112 (direct fired)

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Air Heaters
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Combustion & Heat Transfer Equipment

and unfeathering accumulators. Engines are two Lycoming O-360 rated at 170 hp. at sea level. Propellers are Hartzell full-feathering variable pitch with constant speed governors. Fuel is carried in two 20-gal. inboard rubber bladders and two 30-gal. outboard leading edge tanks. Nacelles and nose are of flush mounted glass fiber.

Super-V empty weight is 1,900 lb.; gross is 3,400 lb. Speed at 75% power is specified as 203 mph.; at 65% power 196 mph. Red-line speed is 252 mph. indicated. Rate of climb is 1,550 fpm., service ceiling is 23,000 ft. On one engine comparative figures are 400 fpm. and 10,000 ft. Range at 55% power is 1,400 mi. and endurance 7 hr. 20 min.; at 75% power range is 1,200 mi. and endurance 5 hr. 50 min. Aircraft is listed as a new airplane by the FAA, with new serial number and new manufacturer's name plate. Certification was expected this month.

Among equipment displayed at Reading were the following:

• **Vecto flight system.** Instrument, produced by Vecto Instrument Corp., Houston, Tex., shows attitude performance; reduces to one instrument speed, directional and climb angle control, and aids in reducing workload during holding and approaches. System includes a flight path computer, mounted and attached alongside the Vecto gyro horizon. Computer's pointer reference marker extends across the face of the gyro horizon, while indices make available to the pilot a fixed attitude reference angle for takeoff or approach.

Gyro horizon presentation includes pictorial display for both flight path and aircraft performance. Directional control is obtained by expanding roll index through installation of a triangle flight track. The system's computer mode may be set for a variety of maneuvers and performance, including cruise all engines, engine-out en route or on takeoff, approach and descent. Exchange price, air driven or electric, is $1,515; outright purchase price is $1,765. About 200 have been sold.

• **Bendix navigation-radio aids.** Alternate track Vortac computer, holding pattern programmer and a "to-from" beeper are produced by Bendix Eclipse-Pioneer Division, Teterboro, N. J. The alternate track Vortac computer tracks to any location (to a "phantom" Vortac) within range of Vortac station, and can be adapted to Tacan. Computer continuously solves a triangulation problem consisting of four factors of information: bearing to "phantom" from Vortac, distance to "phantom" from Vortac, bearing from Vortac to aircraft, distance from Vortac to aircraft.

The holding pattern programmer, designed for use with existing automatic flight control systems or flight director

The 1960 Cessna Line!

Equipped with Macwhyte control cables

Cessna's great new line for 1960 offers the businessman/pilot new power, new comfort, and new jet-sweep styling at realistic prices.

Newest addition to the Cessna family — the Skylark — combines luxury and convenience features of high-priced planes with the economic advantages of economy-priced craft. Exclusive "Flight/Sweep" styling, deluxe interiors, turn and bank indicator, rate of climb indicator, landing light, and other flight aids are a few of the extras that are standard equipment on the Skylark.

Cruising at a comfortable 142 mph, at 70% power and at 10,000 feet altitude, the sleek 4-passenger Skylark has a range of 760 miles.

The Skylark and all the other 8 models in the famous Cessna line are equipped with Macwhyte "Hi-Fatigue"® control cables.

Macwhyte "Hi-Fatigue" Aircraft Cable is made in a complete line of types and sizes. Macwhyte "Safe-Lock" Cable terminals of stainless steel are available loose or in complete assemblies ready for installation.

Macwhyte aircraft cables, terminals, tie rods, and assemblies meet the requirements of aircraft manufacturers, airlines, and military specifications. You can have a copy of Aircraft Catalog A-3 free on request.

223

CESSNA 210

CESSNA 150

CESSNA 310d

CESSNA 172

MACWHYTE Wire Rope COMPANY

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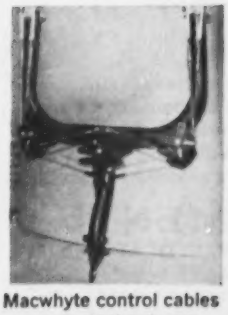
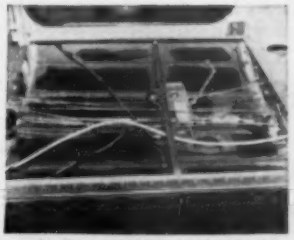
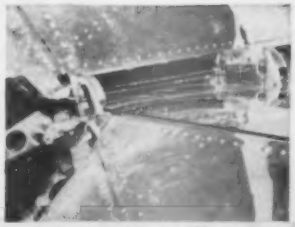
CESSNA SKYLARK



Macwhyte control cables on control column



. . . in floor section under cabin



. . . at base of rudder, on top of horizontal stabilizer

CESSNA 182

CESSNA 175

CESSNA SKYLANE

CESSNA 180

KLIXON®

CIRCUIT BREAKERS, PRECISION THERMOSTATS, SWITCHES and OVERHEAT PROTECTORS

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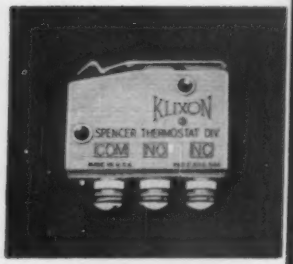
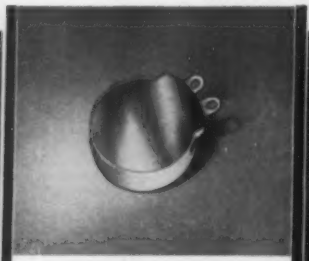


KLIXON KX-5 SERIES PRECISION SWITCHES

Hermetically sealed snap-acting limit switches. Seal uses metalized ceramic terminal inserts and metal diaphragm. Switching element, one-piece sine blade. Steel case withstands high impact and compression loads. High temperature resistance to 375°F. Vibration resistance to 25 g's, 0-2500 cps. Ratings to 10 amperes, 115 VAC or 30 VDC resistive. 25,000 cycles minimum life. Ambient temperatures range, −65°F to +375°F. Weight 1 oz. Variety of actuators available.



NEW KLIXON 4280 THERMOSTAT

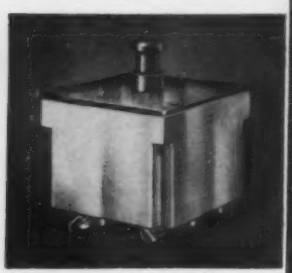
Snap-acting disc type control designed to control temperature within narrow limits. Can be supplied to open or close on temperature rise for control or warning in guided missiles, aircraft, electronic circuits, servomechanisms, gyroscopes, surface heaters, etc. Radius: 0.425. Depth: 0.315 max. Ratings up to 6 amps. 30 VAC/DC; 4 amps. 125 VAC; 2 amps. 250 VAC.

NEW KLIXON 2962 PRECISION THERMOSTAT

Positive temperature control for three-phase systems. Hermetically sealed, fixed temperature, snap action. Controls three phases simultaneously. Temperature settings from −65°F to +325°F. Minimum differential: 25°F. Rating 5 amperes, 120 VAC, 60/400 cycles. Variety of mounting brackets available.

NEW KLIXON 7274 MICRO-MINIATURE CIRCUIT BREAKER

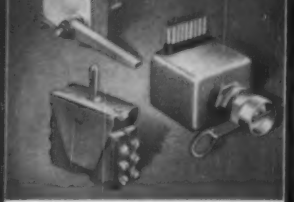
Simple push-pull, trip-free design. Available as shown SPST with 6/32 screw-type terminal or mounting to replace NAF-1357 front-mounted fuse. Also SPDT with N/O auxiliary contacts and 4 solder terminals. Exceptionally small — height 1.420", width 0.744", depth 0.562". Ratings ½ to 5 amperes. Ultimate trip @ 77°F, 115-145%. 200% trip, 2-15 seconds. Vibration resistance 10 g's, 10-500 cps. Shock resistance 25 g's. Weight only 0.9 oz.



NEW KLIXON D6760 SIMULTRIP* CIRCUIT BREAKER

Thermal type, three phase. Interrupts high AC short circuits . . . trips quickly . . . provides simultaneous tripping of all three phases should any one phase become overloaded. Phases can be different ratings. Ratings 5 to 60 amperes. 120/208 VAC, 60/400 cycle systems and 220/440 VAC, 60/400 cycle systems. Weight 227 grams. Minimum AC rupture capacity 2500 amperes, 1 ϕ, 120 VAC, 400 cps. Ultimate trip @ 77°F, 105-130%. 200% trip, 10-65 seconds.

*Trade Mark



PACKAGED PRECISION SWITCHES

The KLIXON KX series, AT1 Type Hermetically Sealed Switches are used as basic units to build packages to fit special applications with varying combinations of connectors and leads. Environment free, metal-to-metal, glass-to-metal sealed. Qualified under MIL-S-6743, MIL-E-5272A, AN3234. The KX4 series has been assigned MS24456 (USAF).

PACKAGED PRECISION THERMOSTATS

Custom designed thermostat packaging to meet special requirements based on KLIXON hermetically sealed MI Thermostats, a highly vibration resistant, snap-acting, non-adjustable type. The MI conforms to MIL-E-5272A, MIL-T-5574A. We provide designing, testing and fast delivery.

NEW KLIXON AT1-1 SUBMINIATURE PRECISION SWITCH

With a 0.440" height, 0.320" diam., KLIXON AT1-1 is a single-pole, double throw, hermetically sealed snap-action switch. Weight: 1 gram. Shock resistant to 100 G's. Vibration resistant to 40 G's, 0-2000 cps. Current capacity: 3 amps., resistive 28 VDC. Environmental free — complete seal assured even at high altitudes. Operates up to 275F. Meets MIL-S-8484A, Class A.

KLIXON Circuit Breakers, Precision Switches, Precision Thermostats and Overheat Protectors are small in size and light in weight; they respond quickly and with accurate repeat performance; they have ample capacity to handle a wide range of electrical loads; their calibrations stand up in the face of severe environmental conditions.

Competent Metals & Controls engineers at the factory and in the field will gladly make test applications of the KLIXON Line. Write for "KLIXON Controls for Electronic Equipment, Aircraft and Guided Missiles" Catalog.

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SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Circle Number 270 on Reader-Service Card

system, relieves the pilot of manually flying a "race track" holding pattern. It flies one or two-minute patterns, automatically sensing and compensating for crosswind and excessive tailwind. The "to-from" beeper provides audio signal and advice, minimizing reference to the "flag" when crossing a station or passing across radial.

Among aircraft on display was a fairly completely equipped Piper Aztec, N45-44P, owned by Max Conrad. Equipment on the Aztec included Goodrich pneumatic deicers guaranteed for 10,000 recharges at 3,000 psi., with energy for 7 hr. action when operated on a 3-min. cycle and Goodrich electrical propeller deicers. Cost of the pneumatic system is $2,600 to $3,000, plus installation costs varying from $600-800. Before FAA will certify a light twin for IFR flights, the wing leading edges, propellers, carburetor, pitot tubes and windshield must be protected.

Comanche 250 on display carried two 15-gal. wing tanks produced by Brittain Aircraft Enterprises, Inglewood, Calif. Tanks allow the Comanche over 2 hr. extra endurance, plus a gain of 3 to 4 mph. at 10,000 ft. Cost of the installation kit, FOB Inglewood, is $895. Tanks (20-gal.) also are available for Bonanza and Navion aircraft. About 350 tanks have been installed on the latter aircraft, allowing for an increase in allowable gross weight from 2,750 lb. to 3,100 lb.

Brittain also had on display its Clarkson flight control, pneumatic two-axis or three-axis system selling with an unconditional one-year guarantee and 30-day return privilege. Two-axis system (roll and yaw) costs from $695 to $745; three-axis runs to $895. Some 280 controls have been installed. Weight runs from 6 to 8 lb. Main components include actuators and control head.

Beacon Receiver

Also provoking considerable interest was Narco's lightweight (18 oz.) MBT marker beacon receiver, a 75-megacycle receiver costing $230. Unit provides a three-light indication and can be connected to an aircraft's audio system for aural identification. Receiver can be mounted vertically or horizontally. Size is 1⅞ in. by 3¼ in. by 7¼ in.

Among manuals on display was Jeppesen's new J-Aid airport and information directory selling for $32 with one year's revision service (on an every-four-week basis); annual revision service after one year is $16. The manual lists navigation and communications frequencies, an airport directory with more than 1,600 airport diagrams, commercial broadcast and direction finding stations, radar approach units and beacon locations, air traffic control procedures and Civil Air Regulations 42, 43, 60, etc.

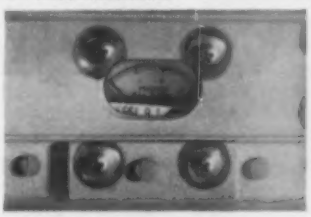
ON EVERY ATLAS COUNTDOWN RMC-LINDSAY PRESSURE GAUGES ARE CONSULTED

Used for Readout of Gas Pre-Charge in Hydraulic System Accumulators

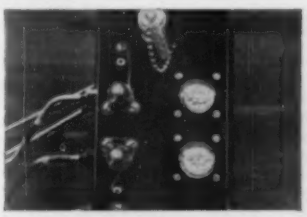
Complete reliability, freedom from jamming even under severe overloads, resistance to shock and vibration, the ability to keep functioning accurately whether setting in the desert sun or subjected to extreme cold . . . these are some of the reasons you will find 6 RMC-Lindsay High Pressure Gauges on each Convair Atlas.

These gauges must withstand shock tests of 100Gs. They are checked for accuracy in vibration tests ranging from 10 to 2,000cps at 35Gs and at ambient temperatures from −65°F to +275°F. *There is no linkage, no gear train to disintegrate or to cause pointer vibration. The indicating pointer is attached directly to the end of the helical bourdon coil.*

RMC Gauges are built to the most exacting laboratory standards for accurate performance under the most rigorous conditions encountered in modern industry, in jet aviation, in astronautics.



RMC Gauge for the booster engine hydraulic system accumulator is flush mounted on the booster engine compartment for easy reading from the outside.



RMC gauges used on sustainer of engine hydraulic system are mounted on the side of the missile fuel tank beneath a maintenance access panel.

If you have a high pressure gauge problem let RMC engineers work with you in its solution. Write, wire or phone:

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NEW RMC PLANT IN MONROVIA

The new RMC Monrovia, California plant has been specifically designed for full scale plant production of precision instruments without sacrificing laboratory production standards.

Circle Number 271 on Reader-Service Card

MORANE-SAULNIER MS 880 Rallye all-metal sport plane is aimed at flying club market. Tail wheel landing gear also is offered.

French Put All-Metal MS-880 on Market

By Robert E. Farrell

Paris—Morane-Saulnier's bid for the sport plane market, the all-metal MS 880 Rallye, has completed its test program and now is being demonstrated to buyers throughout France.

Rallye first flew in June, 1959, and was shown to the public at the Paris air show that month. Final flight tests for certification were completed at the end of April, 1960.

The Rallye is aimed specifically at aero club needs. With a 90 hp. Continental C90-14F engine, aircraft is offered at factory price of $5,000. With a 100 hp. Continental O200A motor, plus radio equipment, factory price is $6,000. Aircraft is offered with either tail-wheel or tricycle gear. Latter arrangement, preferred by most French aero clubs, costs $160 extra. With tricycle gear, 5 kt. are lost in cruising and maximum speed.

To date no firm orders have been received by Morane-Saulnier. Company's sales effort, however, was launched only recently. Program has been held up due to the fact that only one Rallye prototype exists.

Rallye is a mid-wing aircraft made entirely of low gage sheet metal. Wing is fitted with automatic leading edge slats, wide-span slotted flaps and high-efficiency ailerons. Stall characteristics are moderate, with the aircraft mushing in rather than the nose or wing falling off. Slats banging open give ample stall warning along with slight buffeting.

Roomy cabin features a side-by-side front bench-seat with a smaller seat in rear for a third passenger or baggage. Large canopy slides back along the two main fuselage spars. Bent member fitted over canopy is stressed in case of nose-over accident. Cabin air is conditioned by a unit which mixes fresh exterior air with hot air bled off the engine.

Company claims takeoff and landing performance permits use of landing strips as much as 50% shorter than normally used for aircraft of this class. At a gross weight of 1,565 lb., takeoff run is just under 500 ft. Normal landing run of the Rallye is just under 300 ft.

Landing gear is fitted with lever-mounted wheels which permit easy taxiing on unprepared strips. Brakes are automobile-type, and parking brake is standard equipment.

Normal fuel capacity is 26 U. S. gal. contained in two wing tanks. Tanks are so arranged that they can be pulled out through the wingtips and replaced with two larger tanks with 44 U. S. gal. capacity. Shifting to larger tanks in this manner, company says, has no effect on aircraft center of gravity displacement.

Standard flight instrumentation includes airspeed indicator, altimeter, compass and bank indicator. Engine instruments are tachometer, oil temperature and oil pressure indicators. Three sets of seat-belts and seat cushions are provided. Optional equipment includes one VHF set and one direction finder.

Additional flight and engine instrumentation, plus four-frequency VHF set, are included with 100 hp. Rallye as standard equipment.

Both 90 hp. and 100 hp. models are fitted with a two-blade fixed pitch wooden propeller, the only non-metal unit on the Rallye. Company, however, recommends use of metal propeller.

Morane-Saulnier will also install the 145 hp. Continental O300 engine in the Rallye which gives the aircraft a cruising speed of 110 kt. Maximum weight increase with the 145 hp. engine is 80 lb.

MS 880 Specifications

Weights:	
Empty weight	948 lb.
Gross weight	1,565 lb.
Gross weight with 100 hp. engine	1,654 lb.
Dimensions:	
Span	31.88 ft.
Length	20.34 ft.
Height	8.53 ft.
Cabin width	3.67 ft.
Wing data:	
Wing area	132.40 sq. ft.
Wing loading	12.1 psf.
Aspect ratio	7.7

MS 880 Performance

(90 hp. engine, standard landing gear)

Cruising speed	91 kt.
Cruising speed (100 hp.)	95 kt.
Maximum speed	105 kt.
Maximum speed (100 hp.)	110 kt.
Best rate of climb	532 fpm.
Best rate of climb (100 hp.)	591 fpm.
Range	559 stat. mi.
Takeoff distance	492 ft.
Landing run	295 ft.
Service ceiling	11,500 ft.
Fuel capacity (normal)	26.48 U. S. gal.

MS-880's roomy, high visibility cockpit seats two side-by-side and has space in the rear for a third smaller seat or for baggage.

ALUMINUM IN THE AGE OF CHALLENGE

TODAY, U.S. MILITARY PLANNERS FACE THE GREATEST CHALLENGE IN THE HISTORY OF OUR NATION: THE BUILDING OF A MODERN, EFFICIENT FIGHTING FORCE CAPABLE OF STRIKING ANYWHERE IN THE WORLD AT A MOMENT'S NOTICE. ★ MOBILITY IS THE KEY TO MODERN MILITARY PLANNING. AT THE HEART OF MOBILITY LIE TWO SIMPLE PHYSICAL FACTS: (1) THE LIGHTER THE LOAD, THE FASTER AND FARTHER IT TRAVELS; AND (2) THE FEWER OBJECTS TO BE MOVED, THE LESS TIME, TRANSPORT AND FUEL IT TAKES TO MOVE THEM. ★ ALUMINUM HOLDS THE KEY TO MOBILITY. ★ REALIZING THE STRATEGIC IMPORTANCE OF ALUMINUM IN CURRENT MILITARY PLANNING, KAISER ALUMINUM HAS ESTABLISHED A SPECIAL DEFENSE INDUSTRY SALES DEPARTMENT WITHIN ITS NATIONWIDE ORGANIZATION OF 40 SALES OFFICES TO OFFER BOTH SALES AND TECHNICAL AID FOR EVERY ASPECT OF MILITARY PROCUREMENT AND PRODUCTION. TO RENDER THIS SERVICE, THE DEFENSE INDUSTRY SALES DEPARTMENT HAS AT ITS COMMAND THE VAST RESOURCES AND FACILITIES OF KAISER ALUMINUM.

PLEASE TURN PAGE.

HOW KAISER ALUMINUM HELPS YOU OF MILITARY PROCUREMENT

NATIONWIDE PRODUCTION FACILITIES. Kaiser Aluminum's plant system includes 25 facilities throughout the nation and abroad.

These facilities offer a completely integrated operation from the mining of bauxite in Jamaica to the final production of finished mill products such as sheet, plate, forgings, extrusions, and many others. Here are some important facts you should know about these facilities.

RAVENSWOOD – HOME OF THE 30-MILLION-POUND STRETCHER. At Ravenswood, W. Va., Kaiser Aluminum has recently completed the most modern integrated sheet and plate mill in the world.

One of the newest additions to this plant is a giant aluminum plate stretcher with the industry's greatest pull capacity – *30-million pounds!* The huge stretcher can handle plate 144" wide x 6" thick and 60' long, and opens up new opportunities in the fields of ordnance, cryogenics, naval ships, missiles and aircraft. Along with the 10-million lb. stretcher at Kaiser Aluminum's Trentwood, Washington, plant, the new stretcher makes possible the widest range of stretcher-leveled and stress-relieved sheet and plate in the industry.

Vacuum insulated 13,500 gallon air transportable liquid oxygen tank built of Kaiser Aluminum plate by the Standard Steel Corp., Cambridge Div., Lowell, Massachusetts.

THE INDUSTRY'S ONLY MATCHED HEAVY EXTRUSION PRESSES. At Halethorpe, Maryland, Kaiser Aluminum has two modern plants that together provide a completely equipped, fully integrated extrusion manufacturing operation.

Here are located the only matched heavy extrusion presses in the industry – two 8,000-ton presses. This duplication safeguards production by having tools completely interchangeable from one press to another in case one press breaks down. Also, these matched presses can produce unusual extrusions formerly considered impossible.

Scissoring-type bridge designed by the Corps of Engineers, fabricated with aluminum extrusions, spans 60-foot gaps. Strong 2014-T6 and 6061-T6 aluminum will support heaviest tank.

COMPLETE FORGING FACILITIES. With 31 pieces of heavy forging equipment – ranging from 1500 to 25,000 pound hammers and 750 to 8,000-ton presses – Kaiser Aluminum's Erie, Pa., plant offers one of the most complete forging facilities in the nation.

Aluminum forgings offer a high strength-weight ratio and excellent fatigue strength. They support extreme loads under rugged dynamic loading conditions, yet their light weight allows maximum mobility. Precision aluminum forgings hold close tolerances which reduce machining costs and makes aluminum competitive with traditional, low cost cast iron and steel forgings.

RESEARCH AND DEVELOPMENT. Kaiser Aluminum's Department of Metallurgical Research, Product Development Department, and other specialized technical staffs conduct continuous research resulting in new alloys and applications of particular value to the Defense industry.

Forged aluminum tank treads, produced at Erie under contract with U.S. Army Ordnance Tank Automotive Command, Detroit, Mich., were successfully tested at Aberdeen — save 1,000 pounds per vehicle compared to steel.

MEET THE SPECIAL REQUIREMENTS AND MANUFACTURE

NEW HIGH STRENGTH WELDABLE ALLOYS. A major recent advance has been the development and introduction of new, weldable, high strength aluminum alloys by Kaiser Aluminum. The two new alloys, 5083 and 5086, provide maximum utility, joint strength and efficiency in welded structures, particularly those subject to impact or dynamic loading. These new alloys are now available in sheet, plate, forgings and extruded forms. The alloys, used with new welding techniques, have shown substantial design advantages over weldable aluminum alloys previously available. They also offer good forming properties, outstanding welding characteristics, excellent resistance to corrosion, and improved weld zone ductility.

The LARC-5, developed by the U.S. Army and the Borg-Warner Corp., is constructed of high strength, weldable Kaiser Aluminum alloys 5083 and 5086.

THE ONLY BALLISTIC FIRING RANGE IN THE INDUSTRY. As part of its extensive aluminum armor research program, Kaiser Aluminum has undertaken a program for testing armor plate by establishing a firing range for ballistic testing—the first such facility in the aluminum industry. Located at Spokane, Washington, the ballistic firing range conducts extensive tests on aluminum plate, extrusions, and forgings.

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M-113 aluminum armored personnel carrier achieves light weight for air transportability through use of Kaiser Aluminum alloy 5083 plate in hull section. Designed and built by Food Machinery & Chemical Corp.

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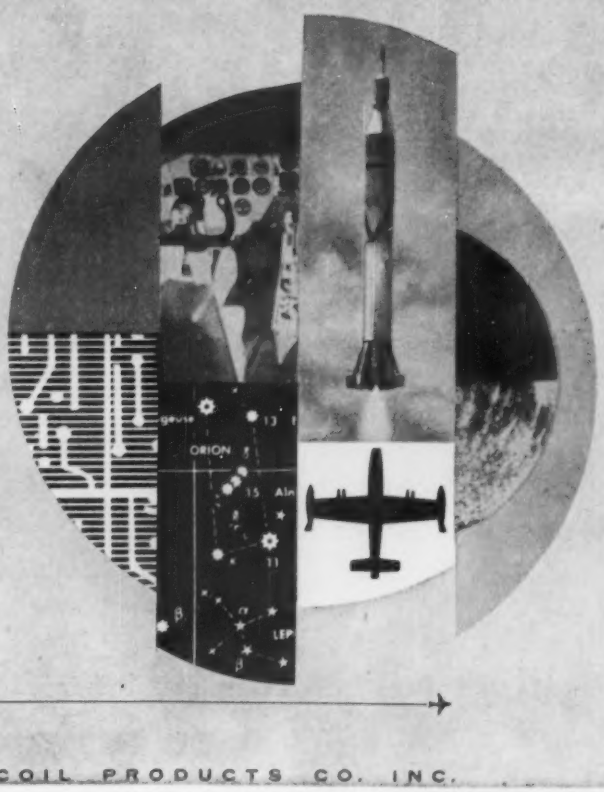

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X-100 vertical takeoff and land test aircraft is seen beginning transition from hover to forward flight. The two-propeller vehicle is powered by a single Lycoming T53 engine.

Curtiss-Wright X-100 Gains VTOL Data

By Barry Tully

Caldwell, N. J.—A small gas turbine-powered VTOL aircraft flying at Curtiss-Wright's Propeller Division is supplying test data for the corporation's planned executive VTOL aircraft. Three prototype aircraft are now under construction at Caldwell with the first flight scheduled for next summer.

The executive aircraft will utilize a new glass fiber radial lift propeller and the company's rotating combustion engine (AW Apr. 18, p. 73), both developed under the direction of Roy T. Hurley, former president of the corporation. Hurley's departure from Curtiss-Wright has led to some speculation on the emphasis to be placed on his programs in the future. Curtiss-Wright propeller people say they expect no cutbacks in the VTOL project.

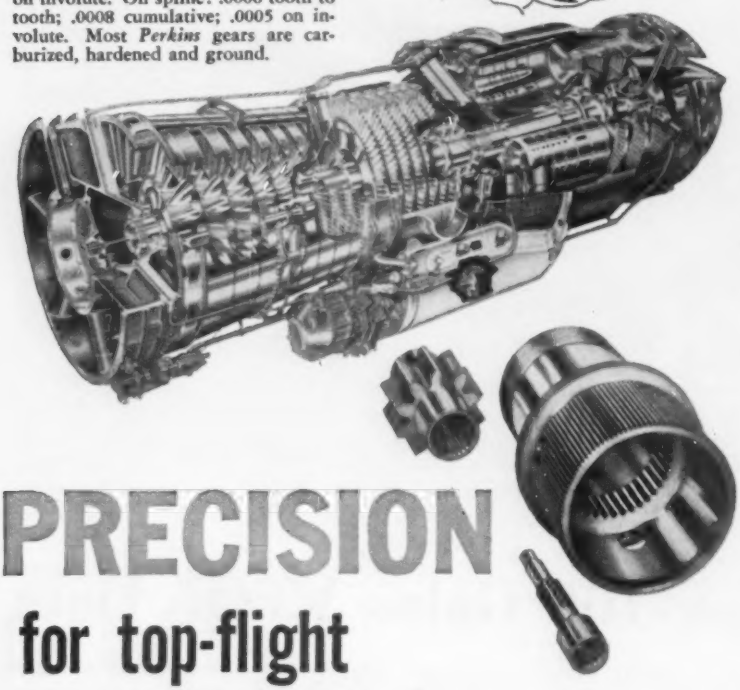
The test vehicle, designated X-100, serves only to test the glass fiber propellers and the radial lift force principle in conjunction with two gimbaled nacelles. The executive VTOL will rely on four rotating combustion engines driving four gimbaled propellers mounted fore and aft. Location of the four engines will provide pitch during hover and low speeds. Pitch control on the two-propeller X-100 is provided by a jetevator mounted aft of the tail. Both aircraft employ stub wings, termed lift struts by Curtiss-Wright, which assume most of the lift at high speeds.

In the event of complete power failure—as in the case of fuel starvation—the aircraft, with engines windmilling in the cruise (horizontal) attitude, can make a normal controlled descent.

The difference between the Curtiss-Wright approach and other tilting-propeller vehicles is that the radial lift

X-200 EXECUTIVE aircraft mockup at Curtiss-Wright's Propeller Division shows large size of the six-place aircraft. Painted area on unfinished mockup marks the pressure cabin. Interior contains four facing passenger seats and two cockpit seats. Unpainted plywood area beneath forward left engine will contain fuel cell. Low ground clearance of the aircraft eliminates the need for door stairs.

Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.



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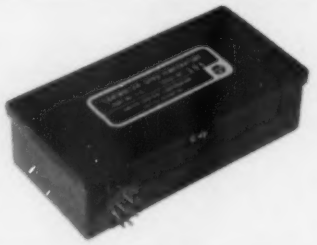

Miniature Control Maintains ±1/4°F

This solid-state device is capable of proportional control of power over a range of zero to 300 watts. Input signal sensitivity in the normal control range is in the order of 5 millimicrowatts. Designed to maintain the temperature of a floated gyro within ± ¼°F by controlling 115 v, 400 cps current to a heater, the unit easily can be modified for other applications where fully-modulated power is required. Normal ambient operating temperature range is +60°F to +160°F. However, the unit performs with minor reduction in accuracy over a range of −65°F to +200°F. Power gain is 10^{10}. With larger diodes and heat sink, proportional control of up to 600 watts is practical. Operating stability and high reliability have been achieved using a basically simple circuit. Development program is complete. The unit is in production and available for early delivery.

CHARACTERISTICS

Power Output: 300 watts during initial warmup of gyro being controlled, with zero to 60 watts after stabilization.

Supply Voltage: 115 volts ± 5% at 400 cps ± 5%

Sensor Resistance: 560 ohms nominal, may be modified for other resistance values

Power Gain: 10^{10} (In normal 20 to 60-watt output range)

Environment: Meets applicable portions of MIL E-5272C

Weight: .44 lbs max

Size: 1.63"x 3.16"x 1.06"

Write for technical bulletin 102

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propellers share the lift load at low speeds, thus permitting higher lift/drag ratios. The lift/drag ratio combined with low specific fuel consumption (0.45) expected of the rotating combustion engine leads Curtiss-Wright to feel that the performance of the aircraft will be a success.

The X-200 executive VTOL aircraft, now being constructed, is a radical aircraft in many respects. Not only does it employ an unusual propeller lift principle, rotating combustion engines and fiber glass propellers, it is long (41 ft.) and heavy (11,000 lb.) for a six-place aircraft. Additionally, the absence of wings necessitates carrying engines, accessories and fuel in the fuselage. In this respect, at least, the aircraft resembles a helicopter.

Project people state that the size and weight constitute the penalty paid to achieve a 400-mph. VTOL aircraft pressurized to fly at 16,000 ft. The 16,000 ft. altitude is not limited by engine performance; in fact, greater economy could be realized at higher altitudes. The 16,000 ft. ceiling was selected as a compromise after considering the range of the aircraft (1,500 mi. maximum), jet traffic at higher altitudes, and the cost and complexity of pressurizing the plane to fly at higher altitudes. Useful load of the X-200 will be 1,200 lb. and maximum fuel load will be 2,000 lb.

The prospect of designing a new aircraft employing a new lifting propeller and powered by a new engine design appears fraught with development pitfalls. The designers state, however, that the Wright Aeronautical Division has promised to deliver the engines as specified and they are plunging ahead on this basis. Design studies have been made substituting four General Electric T58s as powerplants for the aircraft. The lighter, more powerful turbine engines would successfully power the X-200, Wright says, but the specific fuel consumption of about 0.64 would shorten the range of the aircraft. In addition to shortening the maximum range of the X-200 to about 900 mi., the company says the cost of turbine powerplants would be high.

Powerplants in Development

The rotating combustion powerplants for the X-200 are now under development at Wright Aeronautical Division. The supercharged engines will consist of four chambers stacked in series along a common shaft. Each engine will be rated at 600 hp. at an altitude of 5,000 ft. at 100F. Specific fuel consumption of the engine will be about 0.45, according to Curtiss-Wright.

To provide successful three-engine performance, all four engines drive all four propellers. Thus on starting one engine, all four props will turn. Tying the engines to the propellers requires some extensive shafting, adding some 600 lb. to the vehicle.

Curtiss-Wright's Propeller Division is building three prototype X-200 aircraft. Two fuselages will be used for static testing and the three prototypes for testing and certification. In regard to certification, the company will make no estimate on how long it will take to obtain a type certificate for its radical aircraft.

Curtiss-Wright will not estimate the price of the production X-200 at this time, except to say that it will be competitive. The aircraft will cost more than a conventional six-place business plane that is pressurized. Curtiss-Wright, however, is betting that the added cost will be more than offset by the X-200's VTOL capabilities and its high speed. The X-200 can fall short of its design target of 400 mph. and still out-perform all but turbojet business aircraft.

X-300 Proposed

Curtiss-Wright has designed a follow-on to the X-200 which it calls the X-300 local transport aircraft. This is a 40-passenger VTOL aircraft employing gimbaled propellers and more powerful rotating engines. The X-300 differs from the executive version in that the four engines will be in two nacelles—two pull-

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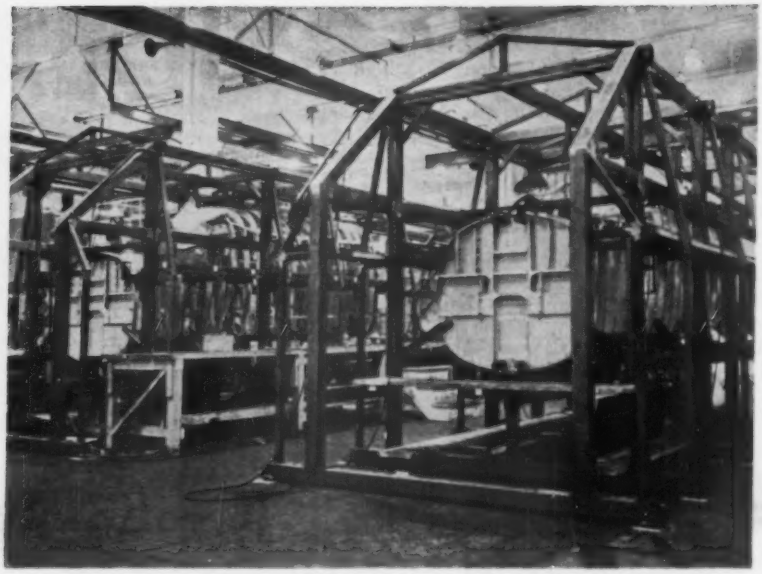

ASSEMBLY JIGS hold the first two fuselages of prototype X-200 aircraft. Curtiss-Wright's Propeller Division is building three prototype X-200s for testing and certification, and two fuselages for water tank and destructive testing.

ing and two pushing. Vertical takeoff and landing is achieved by gimbaling the rear pusher propellers downward 90 deg. as the forward propellers are rotated upward.

The X-300 is still very much in the dream stage and its future rides with the success or failure of the smaller X-200.

Gathering data for these future aircraft is the small single-engine X-100 VTOL test aircraft. Powerplant for the two-propeller X-100 is a Lycoming T53 turboshaft engine rated at 770 shp. Curtiss-Wright leased the engine from Lycoming after securing its release from the Army Transportation Corps.

The two-place experimental aircraft weighs 3,500 lb., is 24 ft. long and measures 16 ft. between the propeller hubs. The propeller tip speeds of the X-100 are 625 fps. on takeoff and 550 fps. at cruise. This compares with the X-200's 800 fps. on takeoff and 650 fps. at cruise. The low tip speed is intended to lower prop stresses and increase blade life.

The propellers on the X-100 are three glass fiber blades fitted to steel shanks. The blades are formed by means of a vacuum process and are filled with glass fiber filler. The surfaces of the blades are covered with an erosion-proof coating to extend blade life. The company says that the chief advantage of the glass fiber propellers, which are about 10% lighter than hollow steel blades, is that they are less expensive to produce. The propeller blade is broad with considerable twist.

The primary purpose of the X-100 is to prove the radial lift principle on a flying vehicle. The propellers gimbal from the perpendicular to within 12 deg. of the horizontal. Gimbal speed is 2 deg. per second.

Hover tests of the aircraft began in

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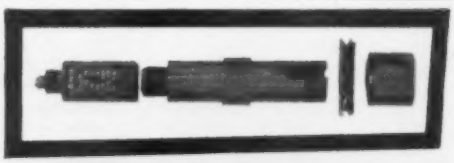

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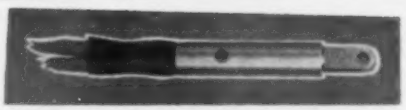

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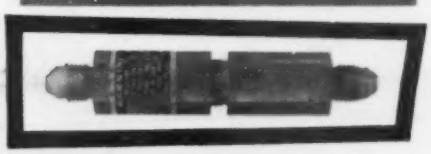
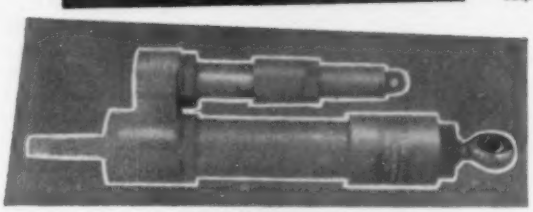
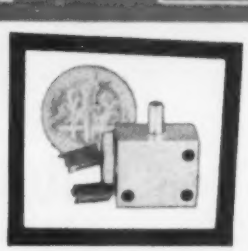
for direct or linkage actuation—with two complete and totally independent ignition systems.



Ballistic Delay Initiator, Model No. 367
for delayed or instantaneous gas initiation—can be modified for various delay and/or pressure outputs.



Cartridge Actuated Thruster, Model No. 298
Locked before firing and at end of stroke. Can be modified for either gas or electrical actuation.

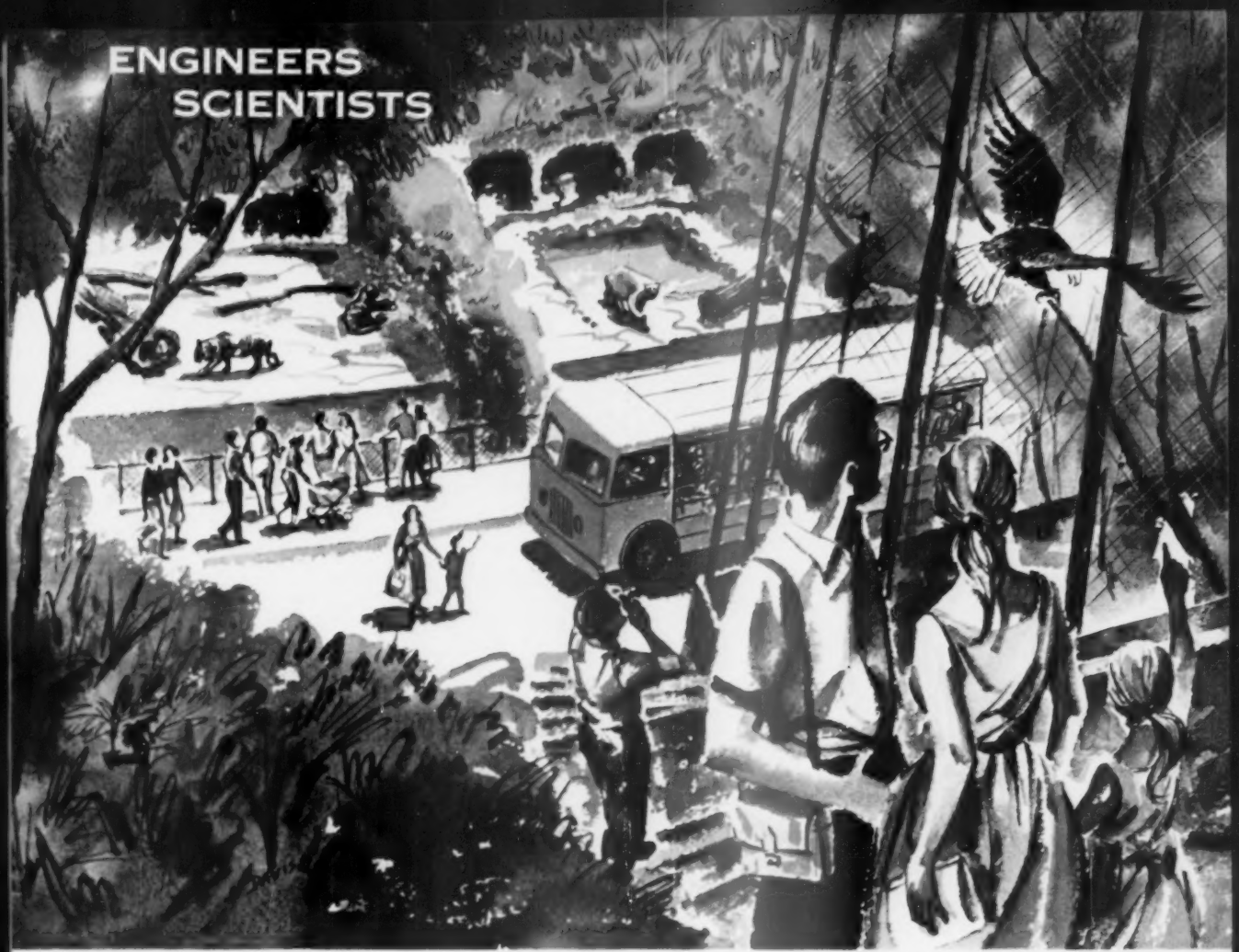


Sub-miniature Actuator
Available in "push" or "pull" action, in a range of strokes and force outputs. Designed to replace solenoids in many aircraft and missile applications.

for further information, write

PROPELLEX

CHEMICAL DIVISION CHROMALLOY CORPORATION
P. O. BOX 187, EDWARDSVILLE, ILLINOIS
PHONE EDWARDSVILLE 3400



San Diego Zoo—An original painting by Jack Davis, Convair/San Diego artist.

Senior and staff-research positions are available now for specialists in Physics, Electronics, Aerodynamics, Dynamics and Thermodynamics at Convair/ San Diego

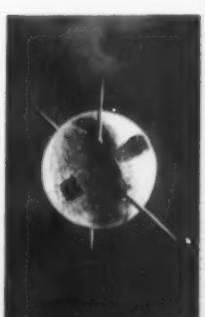
Important, far-reaching work is underway at Convair/San Diego. Professionally stimulating, technically challenging research and development is in progress now on infrared and optical systems, AICBM systems, subsonic and supersonic transports, radomes, aircraft antennas, advanced radar and communications systems.

Recoverable boosters, microwave components and antennas, STOL/VTOL aircraft, high altitude nuclear burst effects studies, guidance systems and submarine detection systems.

These programs require engineering and scientific talent of unusual calibre. If you have a record of versatility and welcome the stimulation of new ideas, we invite your inquiry. It will be promptly acknowledged.

Further details appear on the next page.

CONVAIR/SAN DIEGO



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MAIL ZONE 6-128

(FOLD HERE)

PROFESSIONAL EMPLOYMENT INQUIRY

This information will enable the professional staff at Convair/San Diego to make a preliminary evaluation of your background. A personal interview can be arranged in your city by appointment. Every completed inquiry will be acknowledged.

PERSONAL INFORMATION
(Please Print.)

(FOLD HERE)

Name_____

Citizen of what country?_____

Street Address_____

City and State_____

Phone_____ Closest Major City_____

EDUCATION: College Graduate: Yes ☐ No ☐

Degree: BS ☐ MS ☐ PhD ☐

MAJOR SUBJECT: Physics ☐ Mathematics ☐

Electronic Engineering ☐ Electrical Engineering ☐

Aeronautical Engineering ☐ Mechanical Engineering ☐

Other_____

EXPERIENCE: Primary Specialty_____

Secondary Specialty_____

YEARS OF EXPERIENCE IN PRIMARY SPECIALTY:_____

Additional Comments, if any, concerning your job interests_____

(TEAR HERE)

ENGINEERS AND SCIENTISTS

ASSIGNMENTS ARE IMMEDIATELY AVAILABLE IN THE FOLLOWING AREAS (MS or PHD degree required for most positions):

PHYSICS — Experimental and theoretical work in plasma microwave interactions and magnetohydrodynamics, infrared radiation, solid state physics, nuclear physics. (The Physics Group encourages work in individual field of interest and publication of unclassified papers).

ELECTRONICS — Solid state specialists, circuit design.

AERODYNAMICS — Research and development of subsonic and supersonic jet transports, advanced space vehicles, VTOL/STOL aircraft, missile systems.

DYNAMICS — Stochostic processes and information theory, unsteady air forces, transient loads.

THERMODYNAMICS — Research in heat transfer and rarified gas dynamics, advanced propulsion systems, hypersonic gas dynamics (involving both thermo and aero), fluid dynamics, gas dynamics.

THE ARTIST — Jack Davis, Convair/San Diego artist whose illustration of San Diego's zoo appears on the preceding page, is a native Californian. He was born and raised in Southern California, and following eight years in the Navy, returned there to study at world-famed Art Center School.

After graduation, he spent a year in Chicago as an artist before returning to California. A family man with two children, Davis has been with Convair/San Diego seven years.

CRUISE CONFIGURATION of the X-200 is shown in this composite photo of a model. In this condition ailerons on the forward lift struts and elevators on the aft struts will afford flight control. The four engines are located high in the fuselage between the lifting surfaces. Aircraft would be pressurized to fly at 16,000 ft.

September, 1959, and the first transitional flight was made in April, 1960.

The X-100's jetevator makes landing out of a hover a rather tricky maneuver as a sudden retarding of the throttle causes the tail to slam onto the ground. The aircraft was intended to be conventional in its landing gear; however, pitching problems during early flight tests necessitated the addition of two wheels forward to prevent the aircraft from pitching down on its nose (AW May 2, p. 82).

Pitching problems were corrected by moving the center of gravity point from 3 to 5 in. forward of the gimbal point.

The X-100 is difficult to hover if the wind is in excess of 10 kt. It can be flown conventionally by gimbaling the engines to the cruise position and making a rolling takeoff. The difficulty experienced in acquiring flight test data at Caldwell Airport is indicated by the 180 hr. of engine time logged in obtaining 7 hr. of flight.

The four-engine X-200 should have more stability than the X-100; it will be designed to translate in all directions at 50 mph. to afford stability during hovering in windy conditions. Ailerons on the forward lift struts and elevators on the rear will provide roll and pitch control while the X-200 is at cruise. Yaw control will be provided by means of a conventional fin and rudder.

The X-100 has been flown by two pilots, Bill Forlick of Curtiss-Wright, and another pilot brought in as a consultant during hover tests. The cockpit controls are conventional as Curtiss-Wright hopes to offer the X-200 as one any pilot can fly.

Additional Tests

Further tests on the X-100 include tuft studies and continued data acquisition on transitional flight. The company also will test an automatic stabilization system it has designed for the X-100.

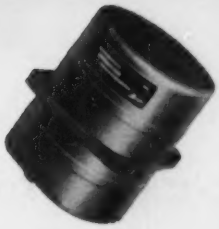
Curtiss-Wright feels that the stability of the four-propeller X-200 will greatly exceed that of the X-100 during hover. The larger aircraft will phase out its propeller pitch lateral control as speed is increased. This is to prevent a yawing moment when the engines are gimbaled forward.

The X-100 does not employ this phase-out of propeller pitch control as its 200 kt. maximum speed—only 160 kt. of which has been reached—and should not create control problems.

AJ-1 Converted to Water Bomber

Bellroy Air Tankers, Long Beach, Calif., has converted three North American AJ-1 attack airplanes into water bombers for fighting forest fires. Conversion carries 2,000 lb. of borate. Company claims AJ will handle twice the load at twice the speed of other such tankers.

BASIC BUILDING BLOCKS FROM KEARFOTT



FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit commard positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #Q2315

Environmental Capabilities
Temperature Range:
(operative): —54°C to +71°C
(non-operative): —65°C to +85°C
Altitude: Unlimited
Vibration: 10g, 10-2000cps

Pickoffs
Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor
Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Momentum:
2.25 x 10^6 gm cm^2/sec

Caging and Preset Provision
(Electrically energized torquer type)
Excitation: 115V max./phase
Torquer Constant:
22.8 dyne cm/$Volt^2$

Performance Characteristics
Free Drift:
5°/minute each axis
Runup Time:
1 minute max.
Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

Write for complete data.

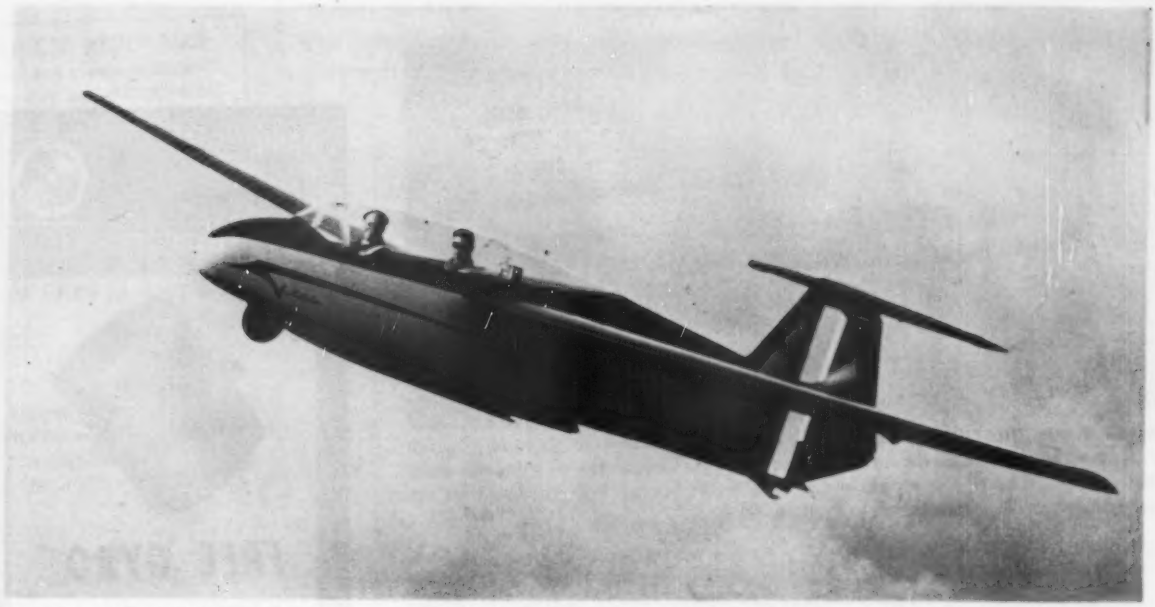
KEARFOTT DIVISION

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

Circle Number 283 on Reader-Service Card 283

Additional Comments, if any, concerning your job



REAR SEAT of the RW.3a is slightly raised so an instructor can have an unobstructed view of the instrument panel.

More Power Marks Newest RW.3 Version

By Edith Walford

Hanover, Germany—Increased power is the major new feature of the "convertible" RW.3a multoplane demonstrated by Rhein-Flugzeugbau GmbH. at the recent air show here.

By fitting wing extensions to the standard RW.3a model, which is approved for aerobatics, it can quickly be converted into a power-assisted glider version, the RW.3b. As a powered glider with dual controls, the aircraft is suitable for simultaneous training of both a glider- and powered-flight pilot.

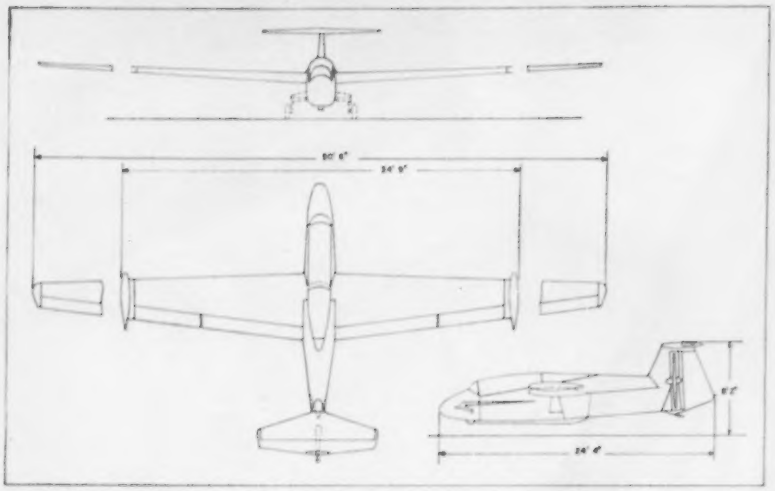
Rhein-Flugzeugbau acquired production rights of the RW.3 in 1957 from Rhein-West Flug Fischer & Co. of Porz-Westhofen, the firm responsible for the original design.

Incorporating some unconventional construction details, first prototype took Fischer about 10 years to develop and put through its initial flight tests (AW Apr. 22, 1957, p. 149). Rhein-Flugzeugbau started license-production at its Krefeld-Uerdingen works on Sept. 1, 1957. First production model flew on Feb. 8, 1958, and was introduced at Germany's first postwar air show at Hanover the same year.

Designed for training, sport flying and touring, the two-seat tandem RW.3a is basically the same plane as the first prototype RW.3. It now has a single 678/4 Porsche engine rated at 75 hp. at 4,600 rpm., replacing the single Porsche 678/0 65-hp. powerplant of previous models.

Novel design feature is the aircraft's pusher-type propeller mounted in a slot

SHOCK-ABSORBER SKIDS are fixed to the RW.3a's plastic-covered fuselage to cushion landing impact on rough ground.



WING EXTENSIONS can be fitted to the standard RW.3a, converting it to the RW.3b.

between fin and rudder. During motorless flight, it can be housed vertically in the slot to reduce drag. The engine is installed in front of the propeller in the rear section of the fuselage. The constant slipstream against the rudder enables the plane to maintain directional stability in any flight conditions when the engine is running.

Technical Description

Standard all-metal mid-wing RW.3a monoplane has extendable laminar profile wings and trailing edge flaps.

The tubular-steel fuselage is plastic-covered, which gives it a very smooth surface and makes it suitable for operation in tropical climates. Shock absorbing skids are attached to the fuselage to cushion landings on rough ground. Cockpit has a full-vision Plexiglas sliding canopy. Rear seat is slightly raised to allow the copilot a good view of the instrument panel.

Main wheels of the tricycle landing gear retract into the fuselage, the castering nosewheel into the nose of the airplane. Landing gear is mechanically operated by a hand lever over prestressed torsion springs. Independent brakes are cable-operated.

The Porsche powerplant with double battery ignition and dry-sump lubrication drives the pusher propeller. A

RW.3 Multoplane Performance

Performance:	RW.3a	RW.3b
Maximum endurance	5 hr.	5 hr.
Normal range	300 mi.	300 mi.
Power loading performance	20.8-26.8 lb./hp.	22.1-26.8
Takeoff distance*	780 ft.	660 ft.
Takeoff and landing speed	47-53 mph.	40-47 mph.
	41-46 kt.	35-41 kt.
Rate of climb	492 fpm.	591 fpm.
	8.2 fps.	9.8 fps.
Maximum speed	130 mph.	124 mph.
	113 kt.	108 kt.
Cruising speed	112 mph.	109 mph.
	97 kt.	94 kt.
Ceiling	14,700 ft.	18,000 ft.
Lift drag ratio	1:16	1:25
Rate of descent	354 fpm.	246 fpm.
	5.9 fps.	4.1 fps.

* Using a variable pitch propeller, takeoff distance is reduced by approximately 20%.

Powerplant:

Porsche 678/4 flat four-cylinder opposed piston engine with reduction gear 1.98:1.
Takeoff power rating 75 hp. at 4,600 rpm—propeller 2,320 rpm.
Maximum continuous rating 65 hp. at 4,500 rpm.—propeller 2,270 rpm.
Weak-mixture power 55 hp. at 4,100 rpm.—propeller 2,070 rpm.
Fuel consumption at economical cruising speed 3.70 gph.

BASIC BUILDING BLOCKS FROM KEARFOTT

SIZE 11 SYNCHRONOUS MOTOR

Featuring pull out torque efficiency of 50% nominal with 3.4 watts input and 3 watts pull out power, this synchronous motor represents a major achievement in terms of performance for a unit of this extremely small size. Additional advantages made possible by Kearfott's unique design include resistance to environmental extremes, light weight construction and low unit cost. This motor and its variations are available in production quantities.

TYPICAL CHARACTERISTICS R172

Excitation:	Phase 1	Phase 2
Voltage	40V	40V
Frequency	400 CPS	400 CPS
Power	2.3 Watts	2.3 Watts
Current	0.157 Amps	0.157 Amps

Performance:

Synchronous Speed	8000 RPM
Stall Torque	0.2 In. Oz.
Pull Out Torque	0.35 In. Oz.
Pull In Torque	0.15 In. Oz.

Write for complete data.

KEARFOTT DIVISION GENERAL PRECISION, INC.

Little Falls, New Jersey

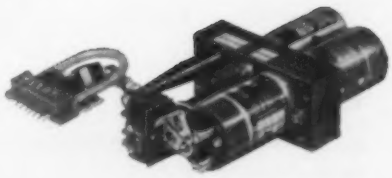
COMPLETE SERVO ASSEMBLIES

We are not an assembly station. We are a manufacturer!

Steel and copper come into our factory. Housings are turned and gears are hobbed from the solid stock. Laminations are stamped from strip steel. Copper is wound right off the reel.

Every operation between raw stock and servo assembly is performed in our own plant, under our own supervision. And because we exercise this complete control over manufacture, we can honestly vouch for the quality and reliability of every motor, generator, synchro, and gear train carrying our name.

Undivided responsibility isn't a new idea by any means, but it is increasingly difficult to find in this age of overspecialization. If you'd care to sample the benefits of this integrated approach, why not call on us now?



SERVO ASSEMBLY – Type 9 motor generator driving two Type 11 CT synchros through a slip clutch and a gear train having ratio of 1500 to 1.

DAYSTROM, INCORPORATED

TRANSICOIL DIVISION **WORCESTER • MONTGOMERY COUNTY • PENNSYLVANIA**

Circle Number 184 on Reader-Service Card

RW.3 Multoplane Specifications

Dimensions:	RW.3a	RW.3b
Span	34 ft. 9 in.	50 ft. 6 in.
Length	24 ft. 4 in.	24 ft. 4 in.
Height	8 ft. 2 in.	8 ft. 2 in.
Wing area	150.7 sq. ft.	193.8 sq. ft.
Span chord ratio	1:7.15	1:12.5
Weights:		
Empty weight	1,322.8 lb.	1,411 lb.
Useful load	661.4 lb.	573.2 lb.
Gross weight (single seat)	1,543.2 lb.	1,631.4 lb.
(two seats)	1,719.6 lb.	1,807.8 lb.
(maximum)	1,984.2 lb.	1,984.2 lb.
Wing loading (single seat)	10.2 psf.	8.4 psf.
(two seats)	11.4 psf.	9.3 psf.
(maximum)	13.2 psf.	10.2 psf.
Fuel capacity	21.1 U.S. gal.	21.1 U.S. gal.

variable-pitch propeller is available as an optional extra. VHF radio and turn-and-bank indicator are among other extra equipment available.

Standard RW.3 is obtainable in the following variations:

- **Short wings** with 34 ft. 1 in. span for acrobatics, training and touring purposes.
- **Short wings** with special plastic wing tip sections fitted. These are shaped like wing tip auxiliary fuel containers, but they are hollow and serve to reduce drag and wing tip vortices.
- **Long wings** with 50 ft. 6 in. span by adding an 8 ft. 2 in. section for gliding, powered gliding, training and touring purposes.
- **More powerful engines** of 100 to a maximum of 150 hp. for training, towed flight, fast touring and for acrobatics.
- **Bigger fuel tanks** holding up to 31.7 U.S. gal. Tank capacity must be specified when ordering the aircraft.

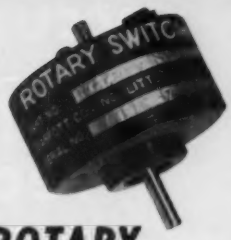
Standard short-wing RW.3a model is priced at roughly $7,450, the RW.3b type with extended wings at $7,825.

U. S. Business & Utility Aircraft Shipments

April, 1960

Manufacturer and Model	No. of Units	Net Billings
Aero Design SCO	2	
560E	2	$722,000
680E	5	
Beech 18S	10	
65 Queen Air	6	
33 Debonair	44	$4,447,000
35 Bonanza	27	
50 Twin-Bonanza	8	
95 Travel Air	13	
Callair A-8	1	$4,000
Cessna 180	24	
172	77	
175 & Skylark	33	
180	27	$5,375,000
182 & Skylane	59	
210	87	
310	26	
Champion 7EC Traveler	5	
7FC Tri-Traveler	6	
7GC Sky-Trac	4	$137,000
7JC Tri-Con	5	
7HC DX'er	2	
Mooney Mk. 20	12	$231,000
Piper PA-18	18	
PA-18 A Super Cub	11	
PA-22 Tri-Pacer	39	
PA-23 Aztec	48	$3,499,218
PA-24 Comanche 180	23	
PA-24 Comanche 250	29	
PA-25 Pawnee	58	
Totals	711	$14,415,218

BASIC BUILDING BLOCKS FROM KEARFOTT



ROTARY SWITCH

Kearfott's rotary switching devices for missile and aircraft systems are used to sequence or switch circuitry as a function of time or shaft position. Used in conjunction with sensitive relays or solid state switching techniques, high current loads can be handled. These switches consist primarily of shaft assembly and bearing mounted cylinder divided into conducting and non-conducting segments with continuous track for common input. Multiple conductor "broom" type brushes ride on each cylinder track while number of tracks and segmentation of each is function of the number of circuits and type of "on-off" sequencing required.

TYPICAL CHARACTERISTICS P1280-11A

Number of switching tracks: 2

Angular Segmentation (both referenced to 0° start):
Track 1 — Non-conducting about 0° + 50°
Track 2—Conducting 0° -180°
Non-conducting 180° -0°

Mechanical Accuracy of Segmentation:
±1° (better as required)

Starting and Running Torque:
0.1 oz.-in.

Current Capacity:
50 ma at 28V/Brush (suitable for any sensitive relay or solid state switching circuits)

Write for complete data.

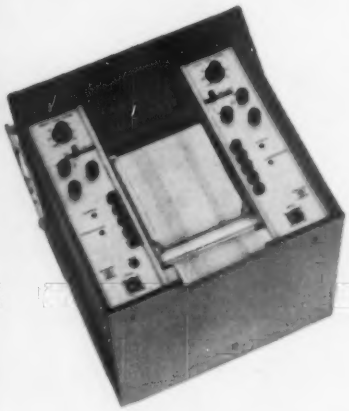
KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

Circle Number 287 on Reader-Service Card 287

keep an accurate graphic record

OF RESEARCH, DESIGN, TEST DATA

two channels



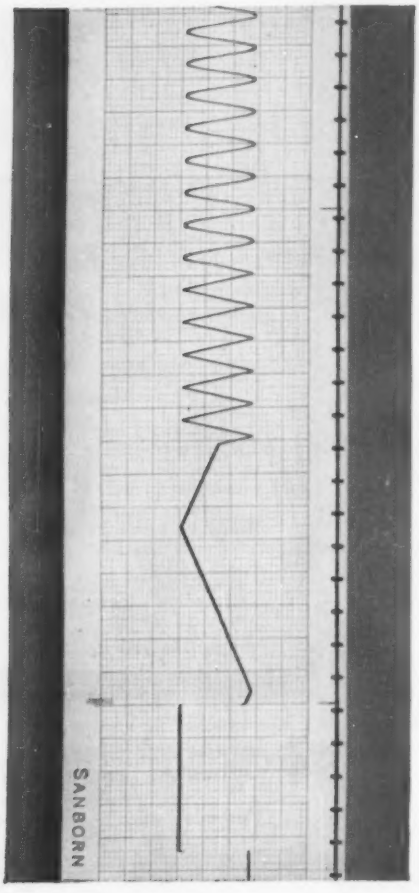
For General Purpose DC Recording — Model 320

For recording *two variables* simultaneously, the Model 320 provides a versatile, transistorized amplifier for each input signal. The rugged 2-channel recorder assembly has heated stylus recording on two *50 mm wide* rectangular coordinate channels, 4 pushbutton chart speeds, and 6 inches of visible chart. The Recorder can be placed vertically, horizontally or at a 20° angle.

MODEL 320 SPECIFICATIONS

Sensitivity: 0.5, 1, 2, 5, 10, 20 mv/mm and v/cm
Frequency Response: 3 db down at 125 cps, 10 mm peak-to-peak
Common Mode Voltage: ±500 volts max.
Common Mode Rejection: 140 db min. DC
Calibration: 10 mv internal ±1%
Output Connectors for each channel accept external monitoring 'scope or meter
Price: $1495

NEW SANBORN PORTABLE DIRECT WRITING RECORDERS FOR IN-PLANT, LABORATORY OR FIELD RECORDING



Two models of this 21 lb. brief case size recorder are available — Model 301 for AC strain gage recording, Model 299 for general purpose DC recording. Both provide immediately visible, inkless traces by heated stylus on 40 division rectangular coordinate charts . . . frequency response to 100 cps . . . 5 and 50 mm/sec chart speeds . . . approx. 4 inches of record visible in top panel window.

single channel

MODEL 301 SPECIFICATIONS

The amplifier section of the Model 301 is an all-transistorized carrier type with phase sensitive demodulator. The power supply and internal oscillator circuits are also transistorized.
Sensitivity: 10 uv rms/div (from transducer)
Attenuator Ratios: 2, 5, 10, 20, 50, 100, 200
Carrier Frequency: 2400 cps internal
Transducer Impedance: 100 ohms min.
Calibration: 40 uv/volt of excitation
Output Connector: for external monitoring 'scope or meter
Price: $750

MODEL 299 SPECIFICATIONS

Combines the dependability of transistors with the high input impedance of vacuum tubes for reliable broad-band DC recording.
Sensitivity: 10, 20, 50, 100, 200, 500 mv/div and 1, 2, 5 and 10 v/div
Input Resistance: 5 megohms balanced each side to ground
Common Mode Voltage: ±2.5 volts max. at 10 mv/div sensitivity increasing to ±500 volts max. at other sensitivities
Common Mode Rejection: 50:1 most sensitive range
Calibration: 0.2 volt internal ±1%
Output Connector: for external monitoring 'scope or meter
Price: Model 299 (with zero suppression) $700
Model 299A (without zero suppression) $650

All prices are F. O. B. Waltham, Mass., within continental U. S. A. and are subject to change without notice.

Contact your Sanborn Sales-Engineering representative for complete information, or write the main office in Waltham. Sales-Engineering representatives are located in principal cities throughout the United States Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION 175 Wyman Street, Waltham 54, Mass.

Circle Number 244 on Reader-Service Card

KEARFOTT developed

and now produces

precise heading and vertical

reference systems

for the B-52 aircraft.

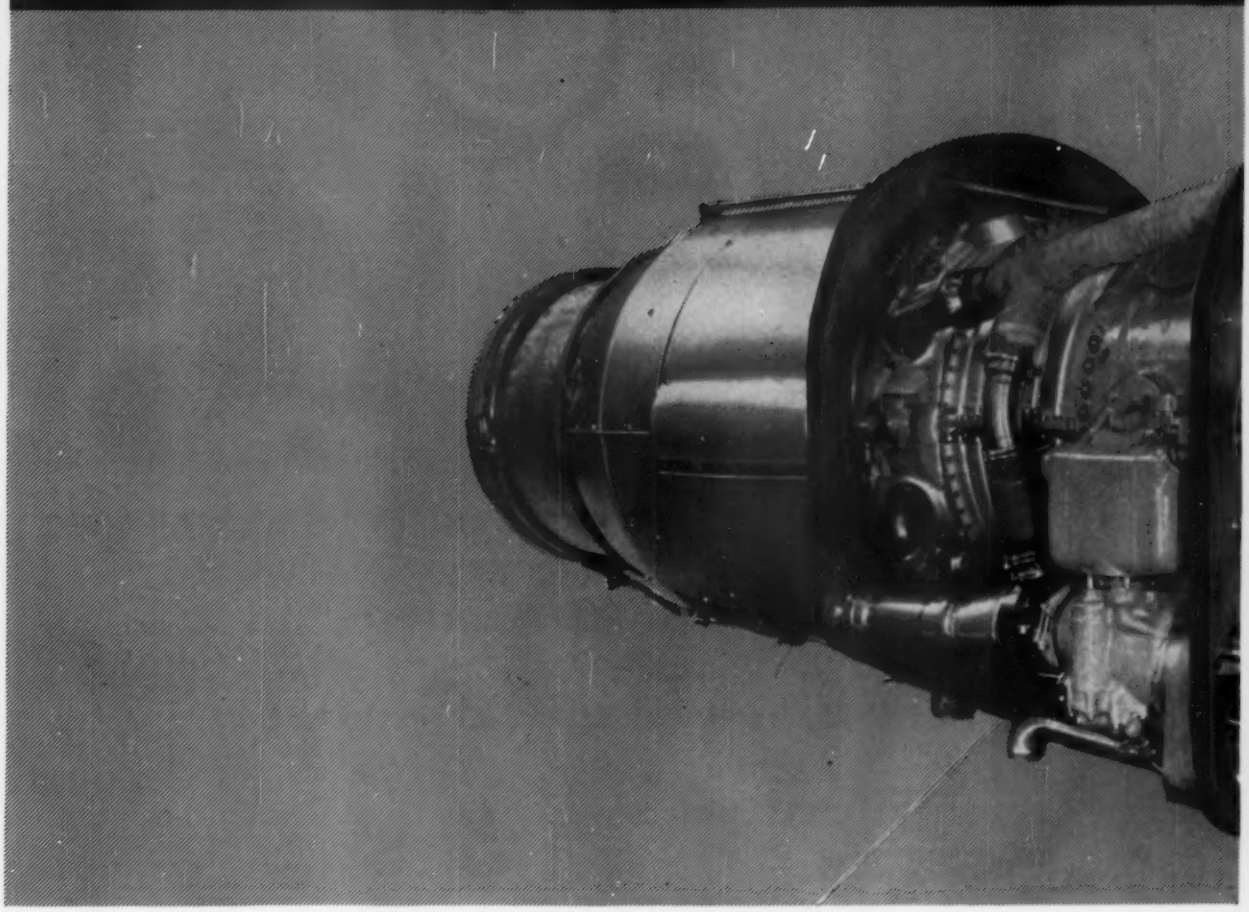
Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

KEARFOTT DIVISION
Little Falls, New Jersey

GENERAL PRECISION, INC.

Circle Number 289 on Reader-Service Card

Latest Olympus version – ready for production –



...ANOTHER ENGINEERING

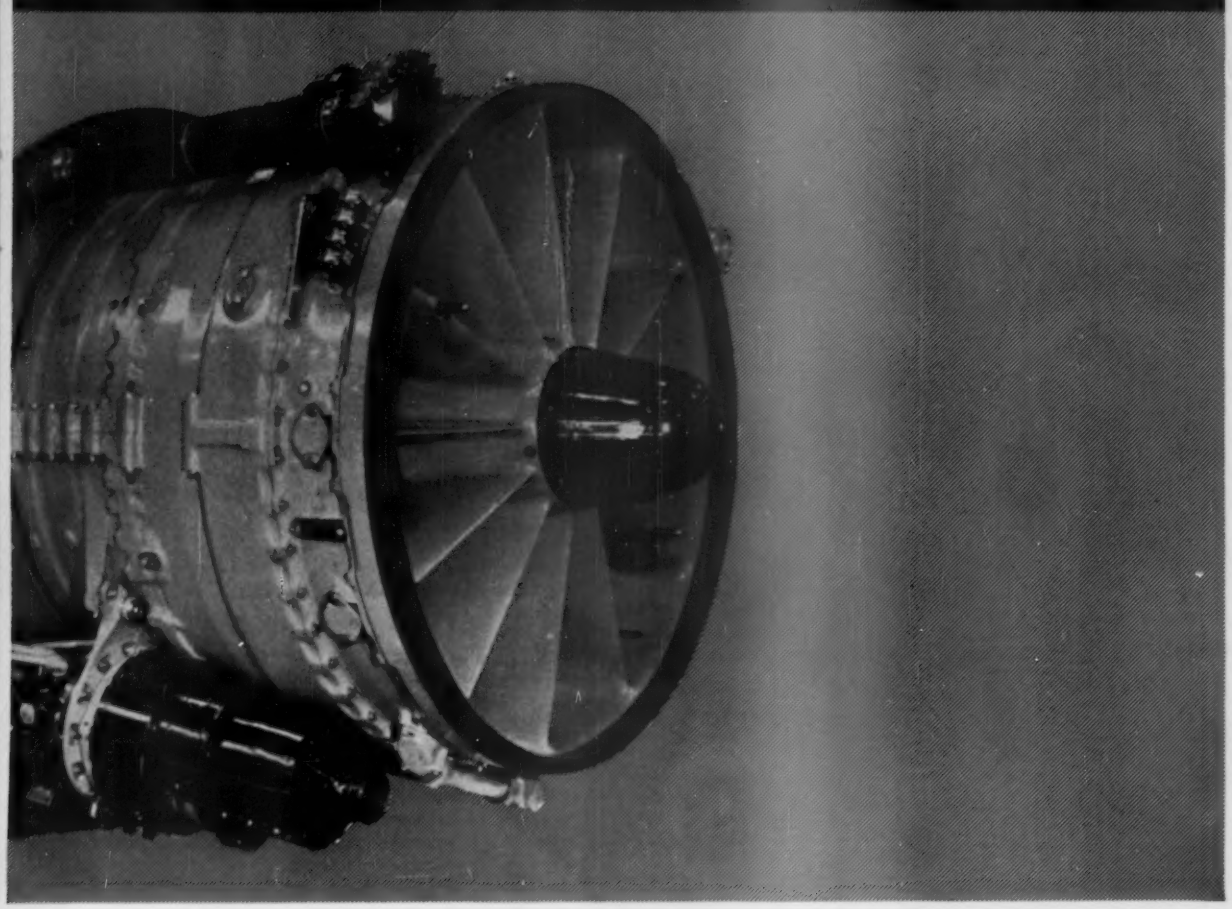
Security restrictions have just been lifted to permit the release of some details of the current Olympus version, the 21, which is now ready for production.

157-in long and with a 42-in intake diameter, the Bristol Siddeley Olympus 21 is Britain's most powerful military aero-engine. It inherits all the outstanding qualities of its forebears—high power at high altitude, unequalled handling characteristics, low fuel consumption and great operational flexibility. It also possesses the highest thrust/weight ratio of any high-thrust turbojet in the world.

The Olympus series of engines owes its excellent all-round performance to the two-spool compressor system, pioneered by Bristol Siddeley and since adopted by the leading aero-engine producers in Britain and the USA. Proof of Olympus reliability is given by the fact that it has the *longest achieved overhaul life*, the *lowest specific fuel consumption* and the *highest thrust* of any bomber or fighter engine in squadron service with the RAF.

The enormous development potential of the Olympus has repeatedly been proved. The first production version delivered 11,000-lb thrust dry, the current Olympus 21 has reached 20,000 lb, and an

- produces 20,000-lb thrust dry...



ADVANCE BY BRISTOL SIDDELEY

even later version is rated at no less than 33,000 lb with reheat.

Olympus applications. The Olympus 201 already gives the Avro Vulcan B 2, spearhead of the RAF's V-bomber force, an all-round performance unsurpassed by any other aircraft of its type. The Olympus 21 has been designed to allow the Vulcan to reach its ultimate design potentialities.

The Bristol Siddeley Olympus is ideally suited to operation at transonic speeds and an advanced version has been selected to power the British Aircraft Corporation's TSR 2, a new tactical support/reconnaissance aircraft chosen for the RAF. Other Olympus versions are under active consideration for the next generation of civil airliners—the supersonic transports.

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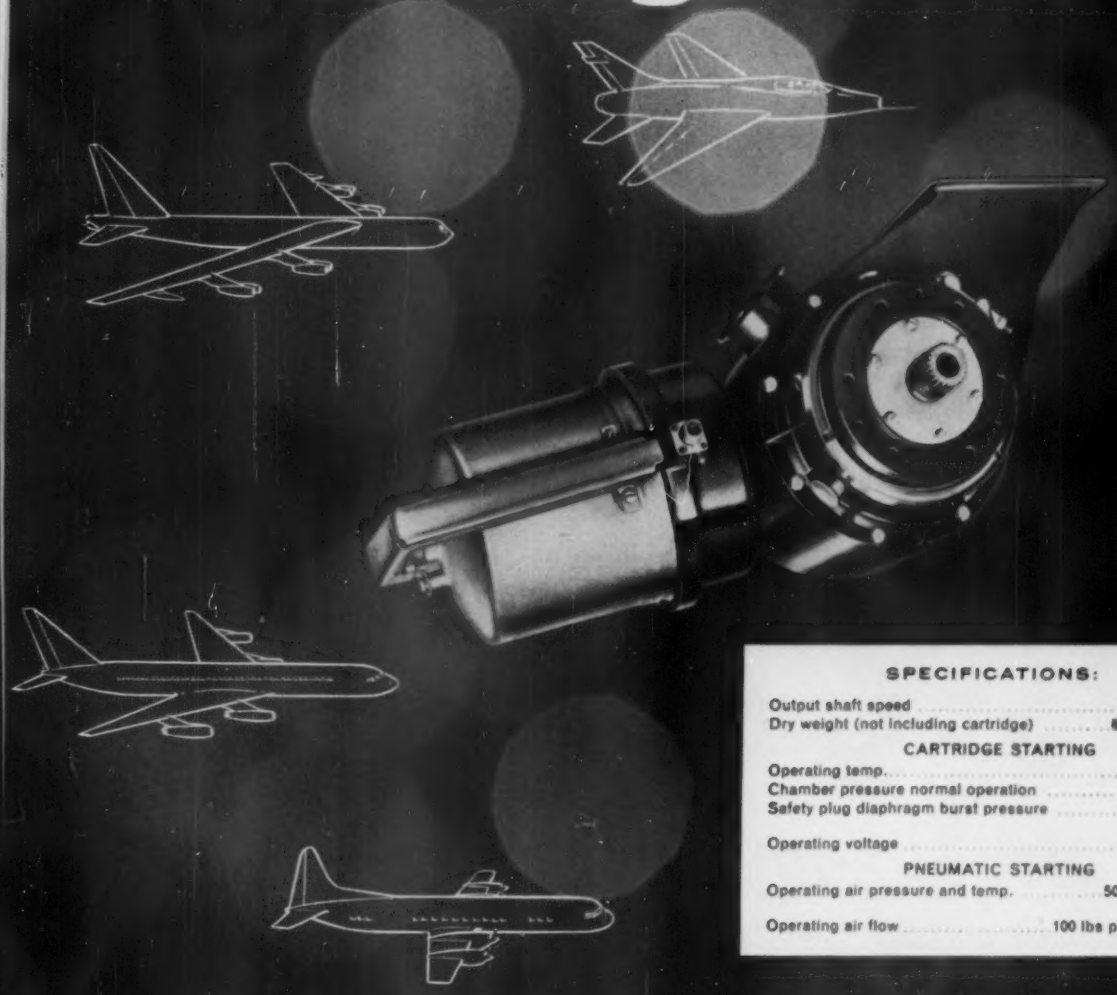

SPECIFICATIONS:

Output shaft speed	3000 rpm (max)
Dry weight (not including cartridge)	60.0 lbs (approx)
CARTRIDGE STARTING	
Operating temp.	−65° to 160°F
Chamber pressure normal operation	850 psi
Safety plug diaphragm burst pressure	2000 psig (nominal)
Operating voltage	15 to 32 volts
PNEUMATIC STARTING	
Operating air pressure and temp.	50 psia and 350°F (nominal)
Operating air flow	100 lbs per min (approx)

AIRESEARCH'S CARTRIDGE/PNEUMATIC STARTER *has completed more than 20,000 successful cartridge starts for the F-100, F-105 and Hound Dog missile applications.*

Completely fail-safe, this lightweight package is the only cartridge starter capable of full containment of a wheel hub burst.

The AiResearch starter is extremely flexible and compact, making it easily adapted to any jet engine envelope. For example, the same starter now used on the Hound Dog missile can be delivered immediately for use on the B-52 itself.

This self-contained, aircraft-installed starting system provides quick, dependable starts in any climate or location by means of high temperature cartridge gases *or* low pressure air such as supplied by an AiResearch gas turbine serving as an onboard pneumatic power source or conventional ground support unit.

The starter consists, basically, of an air turbine starter and a removable solid propellant cartridge chamber. Combustion of the cartridge directs high pressure gas against the turbine wheel, turning the output shaft. Overspeed is controlled by aerodynamic braking action of air compressed by radial blades on the other side of the turbine wheel.

This simple system consists of proven components with many thousands of hours of successful operating history. The pioneer and leading manufacturer of air turbine starters of all types for both military and commercial application. AiResearch has more than four years of cartridge experience and 12 years' experience in pneumatic starters.

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Diversifying Industry to Stress Hard Sell

By Michael Yaffee

New York—Diversification, buttressed by more research and development and hard sell, will play a more prominent role than ever in aviation industry's planning during the coming months.

Most aviation companies are making extensive plans to solve the problem of more competitors and fewer projects in an industry that has gone rapidly from mass to precision production. Survival for some companies, many corporate planners agree, will hinge upon the successful solution of this problem, as weapon system costs continue to rise—assuming a framework of fixed government spending.

Defense Business

On the whole, aviation executives agree that defense business is still desirable. But they now recognize that drastic measures may be called for if they are to maintain a profitable position in the defense market. Not everyone agrees on just what these measures should be, and detailed plans vary from company to company. But from interviews with planning executives representing a geographical and corporate cross-section of the aviation industry, some gross patterns or trends are becoming evident:

• **To some degree,** virtually all aviation companies are expecting a major share of their future growth to come through diversification of product lines, services or markets. Most will devote a part of their expansion efforts to establishment or enlargement of civilian business. Some will direct their diversification primarily along military lines in an effort to expand or maintain their present share of defense business. Others hope to grow through diversification in both areas.

• **Research has become** an integral and important factor in aircraft plans for the future. Total research and development expenditures in this country have more than doubled over the past five years and are expected to double again over the next decade. A major portion of this increment can be attributed to aviation and missile companies. Five years ago many major aircraft companies, fat with production contracts, let less remunerative but vital research work go by default to companies trying to get a foothold in the field, said one electronic company executive. "They are the ones that got the contracts for the next generation of weapon systems, and now we're running to try to catch up with them."

• **More and more aviation** and missile companies are setting up special marketing groups, primarily to strengthen their positions in the defense business. This isn't World War II when the government was obliged to keep its suppliers happy, healthy and solvent, Consultant Salvatore F. Divita told a recent American Management Assn., briefing on the nature of the new defense market. Now it is up to the suppliers to determine what the customer really needs, educate him if necessary and then sell him against top, tough competition. As engineering know-how replaced production capability as the dominant factor in the defense business, says Divita, it in turn is being supplanted by marketing competence. Success in the new defense market for most companies, he adds, will depend primarily on marketing, albeit a technically competent marketing ability.

Diversification for aviation companies means taking on everything from kitchen sinks to electronics. Aeronca Manufacturing Corp. has just about run the gamut. After approaching the brink of bankruptcy, Aeronca got out of the business of producing light aircraft in 1951 and became one of the first companies to devote itself to airframe subcontracting, making major assemblies for large aircraft such as the Boeing B-47, Convair B-58 and Boeing KC-135.

With airframe subcontracting as the backbone of its new postwar organization, Aeronca then made two widely diversified moves, one into the manufac-

Viewpoints on Industry Trends

The aviation industry is entering a crucial decade in its history. Here are some varied viewpoints on the changing complexion of the industry:

• ". . . During the 1960-70 decade the aerospace industry will continue to decline and its character will change by diversification into other product lines, by acquisition of other companies with different product lines, and/or by being absorbed by other industrial organizations with different product lines. By 1970, there will be fewer aerospace companies identified as producing solely aerospace products."—Chance Vought.

• "Misguided enthusiams to take on military work just for the sake of having it in-house can be destructive to both the contractor and to the military. . . . The temptation may be there to use military work as a means of diversification, but competition is now so severe in the military field, and available military funds so limited, that the importance of concentration in those areas where experience and facilities will be the most effective cannot be over-emphasized."—Westinghouse.

• "Diversification of American aircraft companies, started after Korea, is turning into a consolidation trend."—Financial Analyst.

• "Space age means more of the same old business with greater emphasis on flexibility, quality and advanced planning. Manufacturers must stay loose . . . be ready to embrace and able to incorporate changes as they come along."—Martin Co.

• "In five years, rocket companies will be in the same predicament airframe companies are in now. There are already too many companies in the business, all dependent on the military, and the government keeps encouraging new ones to get in when neither the amount of business nor quality of the results justifies it."—Thiokol.

• "We're not concerned with the growing number of small electronic competitors. Most of them serve a valid purpose. What does hurt is the direct support the Air Force has given to major airframe companies in setting them up in the electronics business in order to keep USAF-owned facilities from lying idle as the airframe business dropped off. The electronic companies are partly to blame for this, of course. The airframe companies answered a need that the electronic companies didn't answer fast enough. Six or seven years ago, electronic companies, heavily involved in work on fire control, didn't want to be bothered with the electronic needs of ICBMs, so the Air Force turned to its airframe contractors for this work."—Major electronics manufacturer.

• "The growth rate in the military market since the end of the World War II has represented a compound rate of growth of 11% per annum. However, according to a recent competent estimate of the military market, the growth rate is put at some 3% for the next decade. . . . A slowing down in the rate of growth in any market raises important problems for any firm operating in that market."—Hughes Aircraft.

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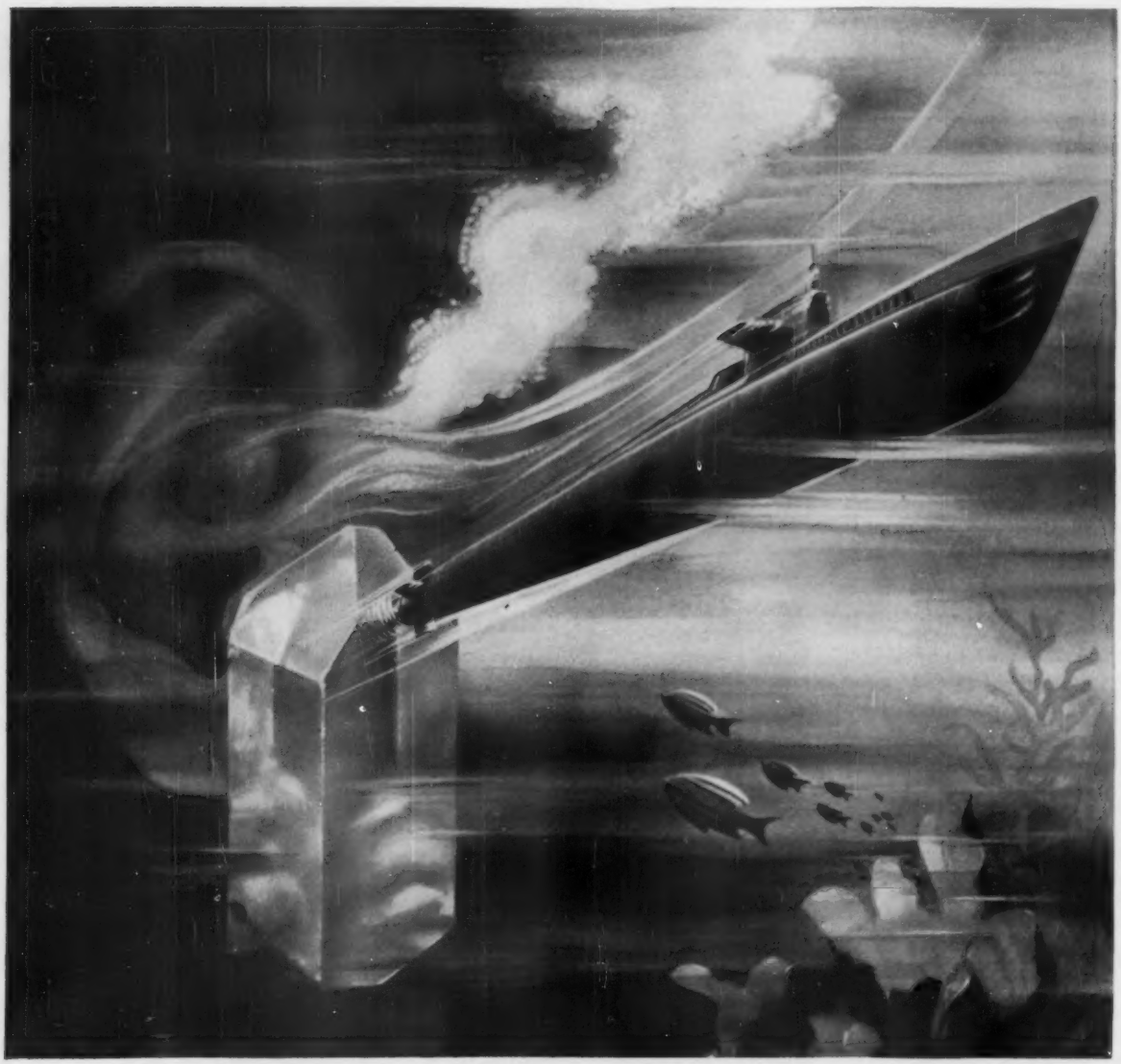
A radical new Passive Underwater Detection System apprehends submarine craft almost intuitively . . . with uncanny accuracy . . . and most important, silently. Developed by Sperry under technical direction of the Naval Ordnance Laboratory, the first of these systems has been delivered to the Bureau of Naval Weapons and has already been used in sea trials termed "highly successful."

Integral in the new system, most accurate and widest-range passive equipment known, is a high speed digital computer and data-processing section. This accepts, operates on, stores and displays instantaneous data relating to the target under consideration. This data is fed automatically into the detection craft's fire control center, and is compatible with present and foreseen target data systems. The computer incorporates both static and dynamic memory, as well as advanced technologies in time measurement, data cross-correlation, digital smoothing, servos, time compression circuitry using quartz delay lines, and accurate time-based generation.

This new system is one of a number of advanced ASW programs in production at Sperry's Surface Armament Division.



SURFACE ARMAMENT DIVISION, *SPERRY GYROSCOPE COMPANY · DIVISION OF SPERRY RAND CORPORATION, GREAT NECK, N. Y.*

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ture of stainless steel sinks for the home and the other into the production of digital computers and other electronic devices for military missile and aircraft systems. Aeronca continued to diversify through acquisition of other firms and through expansion of internal activities. Among other things, the company has gone into the production of the Pogo-Hi III-E3C high-altitude target system, obtained Air Force contracts for work on nuclear space projects and has made prototypes and bids for supersonic target missiles.

At the present time, approximately 75% of Aeronca's business is with the military. But because of its subcontracting to a number of firms and the diversification of its military products, Aeronca feels it is hurt less than aircraft and missile prime contractors by cutbacks and cancellations. Not only does the company intend to stay in the defense market but hopes to bolster its position as a military supplier and subcontractor, relying primarily on its electronic division, expanding its presently small missile and space work, and possibly by additional acquisitions.

Commercial Market

At the same time, Aeronca management is well aware of the desirability of developing its commercial market. It anticipates somewhat harder going in the commercial field, but with kitchen sinks as a starter it hopes to work its stainless steel products deeper into the home and its stainless steel honeycomb into whatever markets may develop. Also, the company has gone into the manufacture of bonded aluminum honeycomb structures and is making containers which are finding their way into commercial markets for such things as food containers as well as into ground support equipment. Recently, Aeronca acquired Buensod-Stacy, Inc., an industrial air conditioning firm specializing in the conditioning of textile and tobacco plants, and United Welding Co., a heavy-metal company that is expected to add to Aeronca's commercial and military capabilities.

In 1958, commercial sales accounted for only 8% of Aeronca's business. By 1961, the company expects this figure to reach 60% with total sales continuing to grow. But the company is not looking for any specified balance between commercial and military. Aeronca's goal, says President John A. Lawler, is over-all growth.

Another company with a somewhat similar program is Chance Vought Aircraft, Inc. Instead of going into the production of kitchen sinks, however, the company went into the manufacture of mobile homes.

In November, 1959, Chance Vought set up Vought Industries, Inc. as a wholly-owned subsidiary to acquire and operate companies making mobile homes. Vought now owns three major mobile home manufacturers with 14 plants in eight states and a combined 1959 sales of $60 million.

Chance Vought also established Genesys Corp. as another wholly-owned subsidiary, specializing in industrial automation. To strengthen its position in this field, Chance Vought acquired last year a majority interest in National Data Processing Corp. which, among other things, is manufacturing a new, high-speed electronic check-handling installation for the Federal Reserve System.

In 1958, Chance Vought had total sales of $333,226,223 of which 99% derived primarily from sale of the Crusader aircraft and the Regulus missile to the Navy. Consequently termination of these contracts in December, 1958, seriously hurt the company. Nevertheless, the company intends to remain primarily a defense contractor. As President F. O. Detweiler told a recent gathering of security dealers and underwriters: "In the process or reorienting the company's sales objectives, it was concluded that our major role should continue to be that of a supplier of highly developed systems and equipment for defense but that we should also start

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to develop appropriate non-military markets."

In order to bolster its position in the military market, Vought realigned its organization, and, in what might be termed an internal diversification move, established five divisional management units—Aeronautics (which covers ASW devices), Astronautics, Electronics, Range Systems and Research.

For companies such as Aeronca and Chance Vought which diversify quickly and widely, there is the potential problem of bringing management capability along at the same pace. To find or organize and run new operations, a parent company often has to peel off its own top management people, leaving the over-all corporate group, at least temporarily, to operate "management poor" in the words of one consultant. But so far, this has not seemed to pose any major problems for either Chance Vought or Aeronca.

Lockheed's Purpose

Lockheed Aircraft is another company that is diversifying heavily but not widely. Its prime purpose in diversifying, says Lockheed, is to augment its capabilities in fields where it already is established.

Originally an aircraft manufacturer, Lockheed moved easily and successfully into the production of missile airframes. Today, it has several large contracts for both missiles and/or aircraft (civilian and military). Most of the firm's recent diversification, however, is aimed primarily at strengthening its position as a military supplier. Lockheed, for example, acquired Stavid Engineering, Inc., an avionics firm which Lockheed merged into a new, wholly-owned electronic subsidiary. It has obtained a major interest in Grand Central Rocket Co., a solid rocket propellant producer.

Recently, the company acquired Colby Steel and Crane Manufacturing, a producer of cranes, hoists and other materials handling equipment, which operates as a wholly-owned subsidiary under the administration of Puget Sound Bridge & Dry Dock Co., acquired last year by Lockheed. Last December, the company obtained a large stock interest in Aeronautica Macchi, an Italian aircraft firm which will build the new Lockheed Model 60 light utility aircraft. Lockheed has also set up two other cooperative ventures, Aviones Lockheed-Kaiser and Lockheed-Azcarate to manufacture light aircraft in, respectively, Argentina and Mexico.

United Aircraft

United Aircraft Corp., historically well diversified within the aviation field, is continuing to diversify; like Lockheed, it is not straying far from areas in which it has established capabilities. Moreover, United is for the most part leaving it up to the individual divisions, each working in a different area of aviation, to carry out its own diversification.

United did establish a new subsidiary corporation, United Technology, as an entree into the solid propellant field. United's Pratt & Whitney Division had already gained a strong foothold in the liquid rocket propulsion field with its development work on the liquid hydrogen-oxygen engines for the Centaur. Pratt & Whitney has also made casings for solid propellant missiles. Additional work in the missile field is being carried out by United's Hamilton-Standard Division which recently took over most of the work and personnel of the company's former Missile & Space Systems Division that was set up to serve as the corporate stepping stone into the space vehicle field.

Pratt & Whitney, still heavy with commercial and military contracts for its new jet engines, has succeeded in finding a novel industrial outlet for its older J57 turbojet. In a joint effort with Cooper-Bessemer Corp., Pratt & Whitney modified the J57 (among other things, it was converted from jet fuels to natural gas) to drive a C-B gas turbine and centrifugal compressor which converts the J57's thrust to commercially usable horsepower. First unit will

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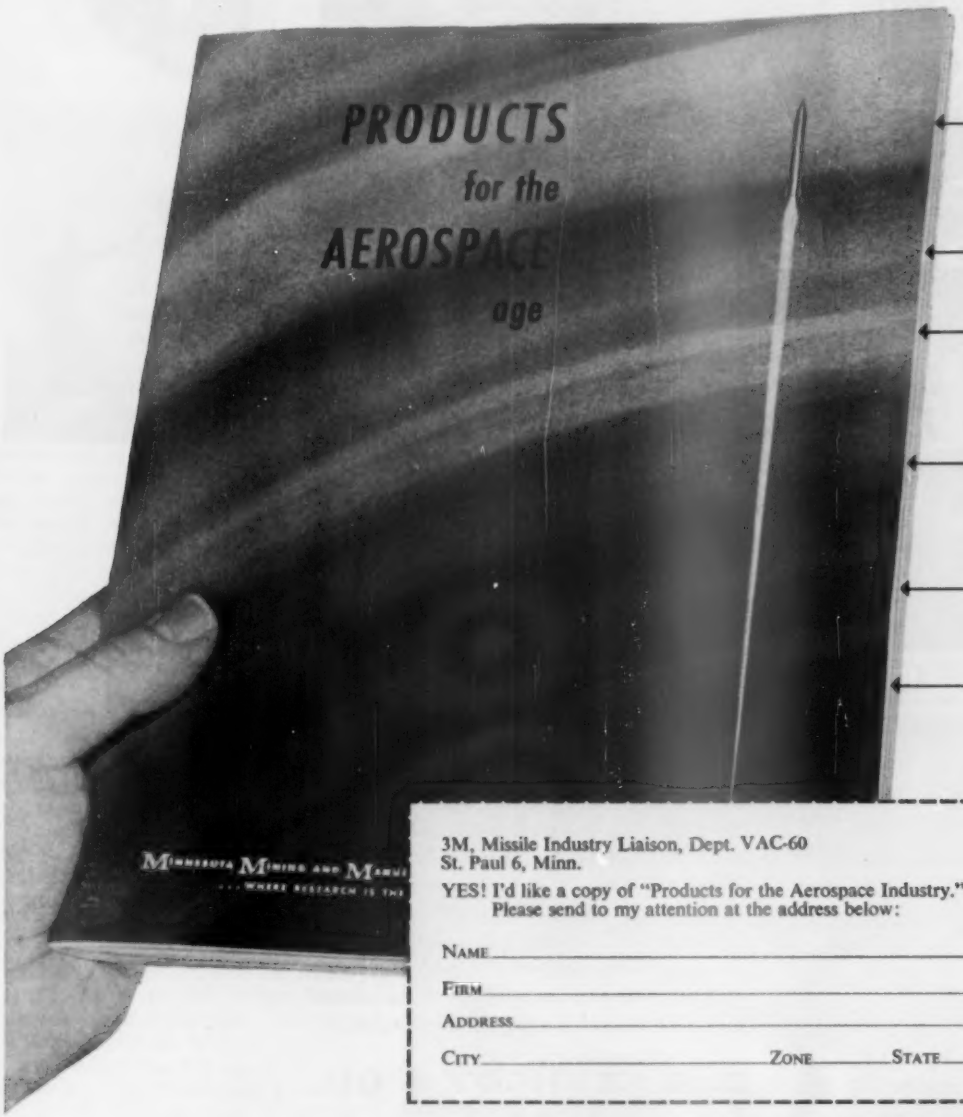

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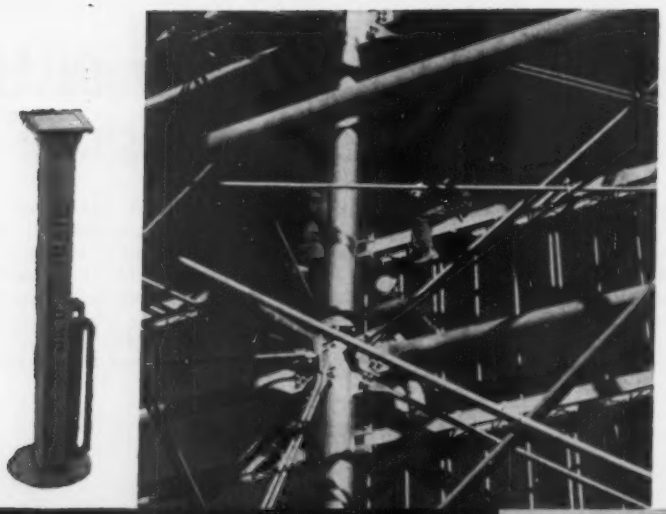

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be used by Columbia-Gulf Transmission Co. to move natural gas through cross-country pipelines. In another joint effort with an outside company, Pratt & Whitney recently entered the auxiliary power field. This work concerns fuel cells which convert chemical energy directly to electrical energy and are expected to find military, space and industrial applications.

Hamilton-Standard Division, still profitably in the propeller business, has diversified into the areas of engine controls and aircraft air-conditioning systems. Last year, Hamilton-Standard established an autonomous electronics organization and a ground support equipment department. It has acquired manufacturing rights to the Zeiss electron beam machining and welding process along with 25% interest in the U.S.-Canadian marketing organization for this process. The division has also acquired a 50% interest in Microtecnica, an Italian manufacturer of precision mechanical and electromechanical devices. Last year, for the first time, services and products other than propellers accounted for more than 50% of Hamilton-Standard's total sales.

To a lesser degree, other United Aircraft divisions and operations are carrying out similar diversification or doing research in preparation for it.

The company believes the bulk of its sales will continue to come from the manned aircraft field, principally in turbine engines and helicopters, for the next several years. Its diversification at this time is intended primarily to serve as a supplement to its present work and as the plinth upon which the corporation's future business can be built.

Republic Aviation's diversification efforts so far have been restricted to the missile and space areas. In addition to the F-105 fighter-bomber for which it has a sizable Air Force contract, Republic is making combat surveillance drones and has built a large engineering, research and development center for work on advanced systems.

The company plans to get into the avionics business and hopes to find an entree to the VTOL/STOL field. At the present time, Republic has no plans to enter or re-enter the commercial transport or personal aircraft market or to go into a non-aircraft field but is not barring these as possible eventualities. In regard to diversification generally, Republic officials are looking primarily for new business that has a profit potential "for our kind of company, with our kind of skills, with our kinds of tooling and facilities, and so on."

ACF Industries has acquired 214,000 shares of Republic stock, and Republic's president, Mundy Peale, has been elected to ACF's board.

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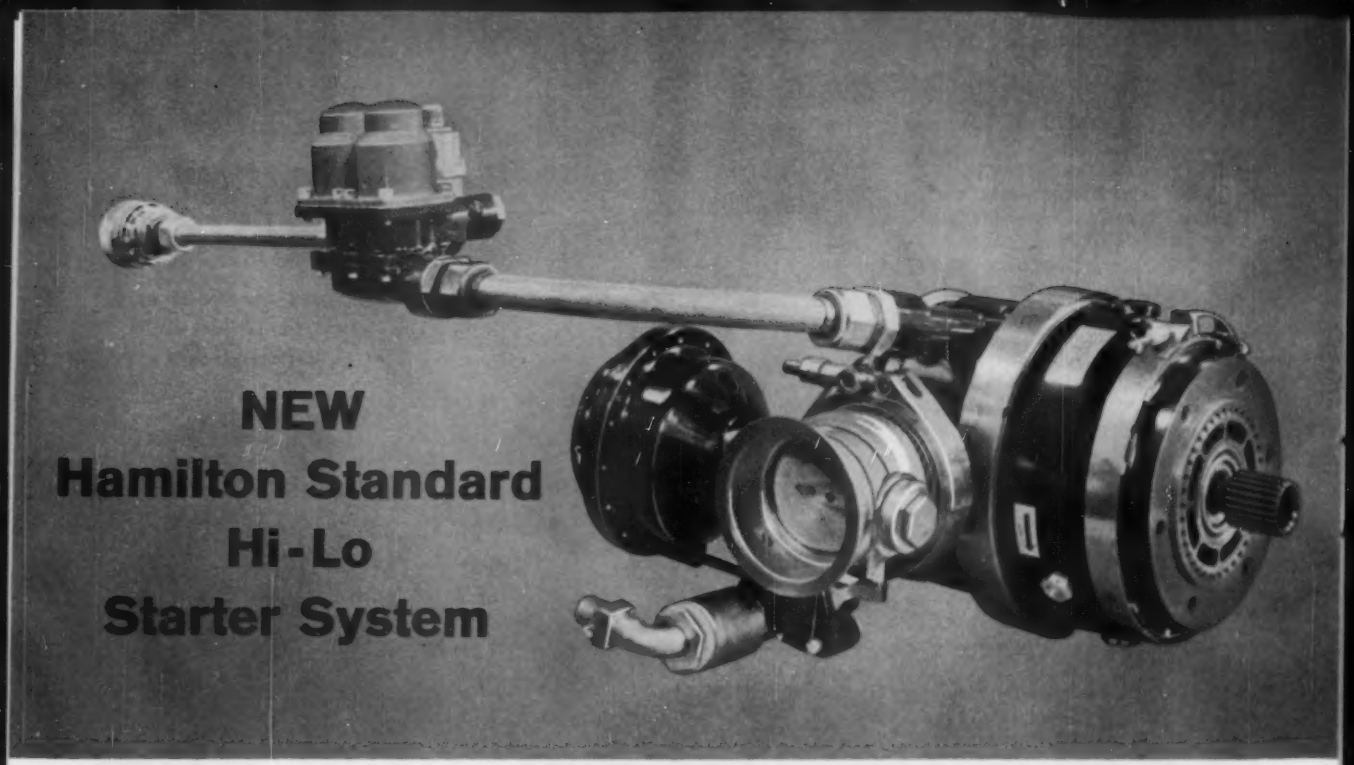

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neighbor, Grumman Aircraft maintains it has no interest in getting into the electronics field. By staying out of this area, Grumman can enjoy the confidences of a large number of electronic companies—a fact which it considers a distinct advantage in serving its primary business of supplying complete aircraft and missiles. Also, with its new development work on hydrofoil boats, Grumman has moved somewhat further afield in its diversification effort.

General Electric, like General Dynamics already well diversified, is also interested in hydrofoil boats, as an outlet for its jet engines. So too are a number of aircraft companies, including Lockheed, Martin, North American and Boeing. In a somewhat related effort, Westinghouse, as part of the Navy's Project COSAG, has installed one of its J34 turbojet engines on a ship where, coupled to a low-pressure turbine, it develops 7,500 shp. and is used to provide vessel flank speed. Lycoming Division of Avco has installed and tested its T53 gas turbine on two hydrofoil vehicles, one a Navy landing craft and the other a modified World War II amphibious vehicle.

Popcorn Machines

Temco Aircraft Corp., a post-World War II entity, began life with a wide diversity of products ranging from popcorn machines and mail boxes to the modification and production of complete aircraft. Foreseeing a decline in the demand for airframes, Temco management carried out a major reorientation of its engineering organization in 1954 and changed over to the weapon systems concept. With this, its interests and activities spread into all the aircraft disciplines, including electronics, missiles and manufacturing research. Meanwhile, the company continued its efforts to expand its airframe manufacturing, aircraft overhaul, vending machine production and other commercial operations.

Last year, Temco carried out another major reorganization and set up its various operations as separate divisions in an effort to encourage each group such as electronics to diversify and develop as it sees fit. Today the company is still heavily involved in aircraft overhaul and airframe subcontracts as well as in vending machines and is desirous of getting and hanging on to as much of this business as possible. At the same time, Temco is moving along into the electronics and missile fields. The company has also set up a manufacturing research department to study new materials and related production processes and has created a small nuclear group to help the company establish a capability in this area.

A sidelight on Temco's missile activities is management's avowed decision to stay out of the big IRBM and ICBM areas. Temco's missile division, now primarily concerned with the Corvus, is geared to develop the smaller missiles either in toto or in part. The company is also interested in working with one or more other companies as a team to bid on missile projects.

For the time being, Temco's diversification philosophy is to expand its industrial and civilian market by building in-house capability and to expand its military market both by building in-house capability and by acquiring other companies.

The company's pending merger with Ling-Altec Electronics, Inc., now up for approval by the stockholders of both firms, apparently represents another step in the execution of Temco's diversification policy, albeit the biggest one to date.

Two-fold purpose of the merger is to give the resultant corporation a strong research and development team capable of rounding out commercial and defense product lines and to strengthen the corporation's position as a major research, development and production group in the highly competitive missile and electronics fields.

The Martin Co., an early aircraft firm, was one of the first to get into the missile business—and out of aircraft as such. Within the chosen field, the

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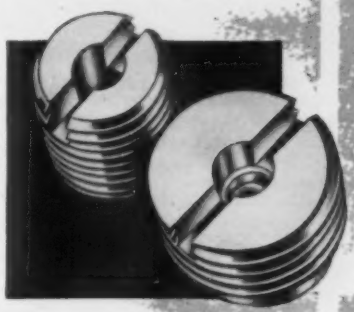

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D. Vibration—	0.30 inch double excursion from 3 to 18 cycles per second and ± 2 g. acceleration from 18 to 500 cycles. (Without vibration isolators)
E. Crash Safety—	Repeated shocks of 30 g. with durations of 11 milliseconds
F. Salt Atmosphere—	Section 4.6.1 of MIL-E-5272
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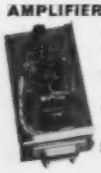
Demodulator Amplifier

Input Impedance— Greater than 25,000 ohms
Output Impedance— 2830 ohms (Dual)
Voltage Gain— Greater than 115
Supply Voltage— 28.0 D.C.

TYPE 9616-07—SYNCHRONIZER AMPLIFIER

Synchronizer Amplifier

Input Impedance— Greater than 50,000 ohms
Voltage Gain— Greater than 250
Load— Control Phase of Motor Generator of 9805-19 or 9805-20

TYPE 9616-16—4-CHANNEL ISOLATION AMPLIFIER

4-Channel Isolation Amplifier

Input Impedance— 1200 ohms per channel
Voltage Gain— .98 ± .01 per channel
Load Impedance— 1200 ohms per channel
Supply Voltage— 48VDC

TYPE 9616-09—SERVO ACTUATOR AMPLIFIER

Servo Actuator Amplifier

Input Impedance— Greater than 50,000 ohms
Output Impedance— 400 ohms
Voltage Gain— Greater than 900
Supply Voltages— 100.0 volts D.C. 28.0 volts D.C.

TYPE 9616-15—RELAY AMPLIFIER

Relay Amplifier

Input Impedance— Greater than 15,000 ohms
Relay Closing Voltage— 150-175 Millivolts, 400 cycles
Relay Opening Voltage— 125-150 Millivolts, 400 cycles
Relay Contacts— 4 Pole, Double Throw—Dry Circuit
Supply Voltage— 28.0 V. D.C.

TYPE 9616-06—SUMMING AMPLIFIER (DUAL)

Summing Amplifier

Summing Inputs— 10 (per channel)
Gain— Nominal 1.0; variable from 0.1 to 10.0
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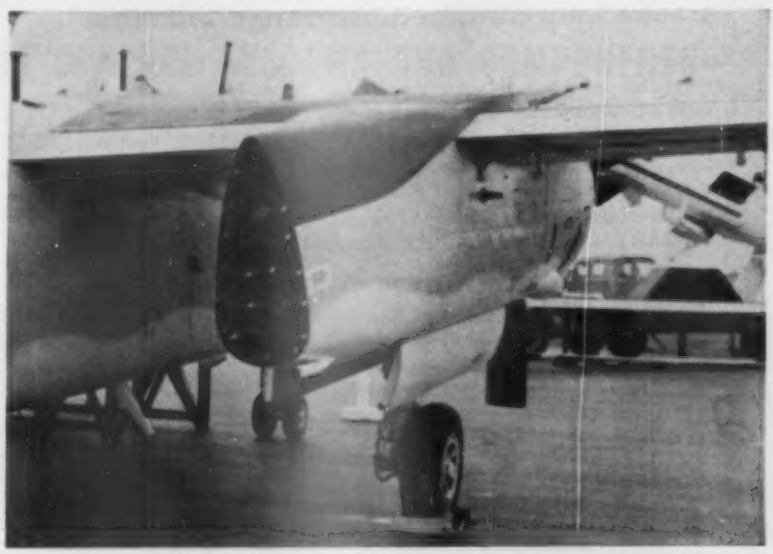
company is pursuing a broad policy of diversification, with the primary emphasis at present on the missiles themselves but including everything from ground support equipment and auxiliary power units to space systems.

Currently Martin, which is probably engaged in the design and production of more military missiles than any other U.S. manufacturer, is making such diversified systems as the Titan ICBM, Pershing selective range artillery missile, the air-to-surface Bullpup, the short-range Lacrosse artillery missile, and the air-breathing Mace tactical missiles. Martin is also working on the Dyna-Soar piloted boost-glide system.

The company is also making the Missile Master electronic air defense system. In January, Martin established a separate electronics division. Last year, ground support equipment accounted for approximately 20% of Martin's business; a percentage of this was for electronic gear. For the pursuit of pure research, the company established RIAS, and for the development of nuclear capability, Martin Nuclear.

Martin expects a large share of its future business to come from the Nuclear Division's present work on nuclear powerplants, components, propulsion systems, advanced reactor systems and isotopic power. Meanwhile, the company is spending large sums of money—"more in one year than was spent on the whole Viking sounding rocket program in eight years"—for research on chemical fuels to improve the performance of present type propulsion systems which are expected to be around for some time. Too, the company sees a large potential market for itself in this country's peaceful rocket and space re-



S2F-3 Nacelle Stores Sonobuoys

Modifications in the Grumman S2F-3 Tracker include increase in nacelle sonobuoy storage from eight to 16, gained by changing the nacelle configuration. Other changes include more fuel capacity, placing electronic countermeasures antenna in wingtips.

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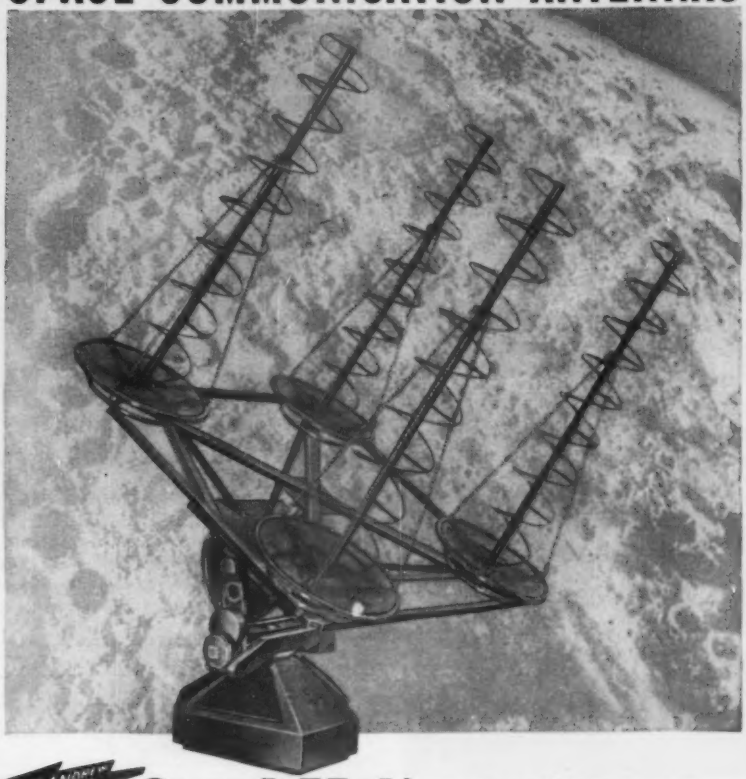

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215-265 mc	10.5 db	H 30140 A
215-265 mc	13 db	H 19110 A-2
260-320 mc	13 db	H 19110 A-3
320-400 mc	13 db	H 19110 A-4
400-500 mc	12 db	H 19110 A-5

DISCONE ANTENNAS

FREQUENCY	TYPE NUMBER
25-50 mc	50154
50-108 mc	51150
108-215 mc	19050-1
215-420 mc	19050-2
420-1000 mc	19050-3

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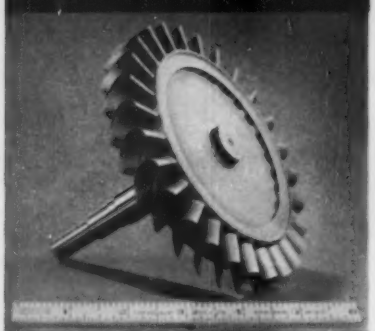

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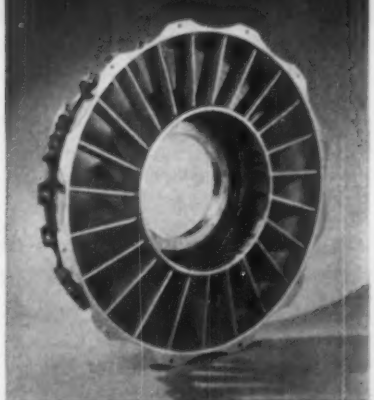

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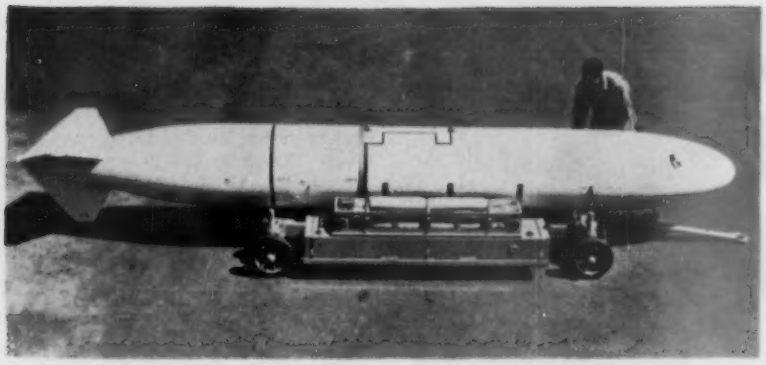

Auxiliary Power Pod Designed for Navy A3J and F4H

External power pod supplies ground support for the Navy's North American A3J attack aircraft and McDonnell F4H fighter. Powered by a combination compressor-shaft power gas turbine, the pod provides 60 kva., 400 cps. electricity, refrigeration for cooling avionic gear and pilot's pressure suit and bleed air for starting the GE J79 engines used in both aircraft. The 1,638 lb. pod, developed by Garrett Corp.'s AiResearch Division, is 26.2 ft. long with a maximum diameter of 2.9 ft.

search programs in which it expects to see a big upswing.

Most of Martin's diversification is defense-oriented and is coming from within the company. At the same time, management is interested in the "possibilities of similar diversification outside the defense industry area and has taken certain steps looking toward early extension of its technical skills and capabilities to the civilian economy." One such step has been the acquisition of approximately 14% of the voting stock of General Precision Equipment Corp. with an eye to the advantages of an eventual merger.

For rocket propulsion pioneer Aerojet-General, diversification has meant, among other things, getting into the aircraft business. With the purchase of Rheem's Defense and Technical Products Division, Aerojet acquired entrees into drone aircraft, flight simulators and large aircraft fuselage section fabrication as well as new capabilities in explosive ordnance.

Since its creation in 1944, Aerojet has grown rapidly and expanded widely. A look at the company's structure shows the following functional divisions: solid rockets, liquid rockets, nucleonics, avionics, explosive ordnance chemicals, anti-submarine warfare, architect and engineering, structural plastics, turbomachinery, systems, and space technology.

Chemical Interests

In addition, the company is engaged in a joint research and development venture on high energy fuels with Stauffer Chemical. In another joint enterprise, Aerojet is working with Bristol Aeroplane on rocket propellants. Bristol-Aerojet also distributes Aerojet products in the British Commonwealth and some European countries. Further diversification into foreign markets has been implemented by a sales agreement with Mitsui & Co., Ltd., of Tokyo which will handle Aerojet products in the Orient.

As a result of this rapid growth and diversification, Aerojet, like many other companies, is faced with the problem

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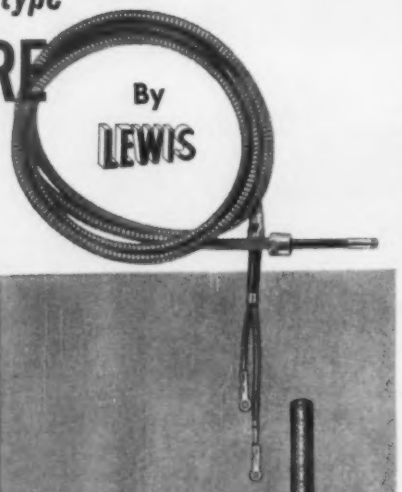

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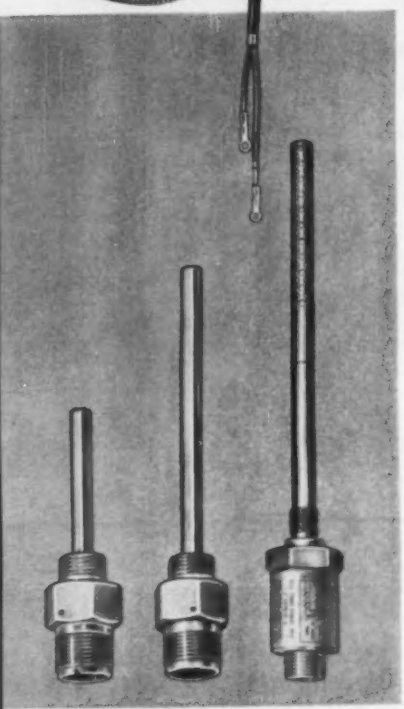

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of trying to expand its management at the same pace as its products without sacrificing the quality of either.

For the most part, Aerojet's diversification has progressed through opportunity rather than planning, and company officials expect it to continue on this basis. When the company saw a need for a certain capability, such as happened with infrared in 1947, that did not exist within the company or adequately and conveniently outside, then the company created its own capability in that area. More recently, as in the acquisition of the Rheem Division and Aerojet's nucleonic subsidiary, the company decided to purchase existing capabilities when the need and opportunity presented themselves.

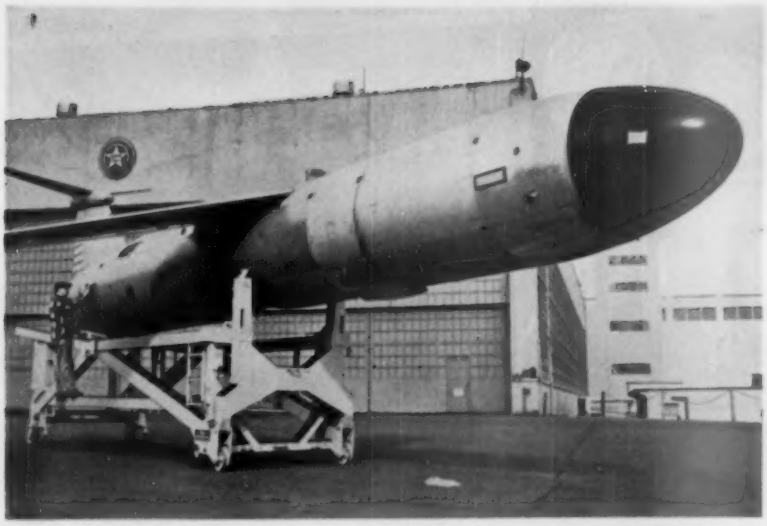
Thiokol's View

Thiokol, another rocket propulsion pioneer, also is vitally interested in diversification. The company estimates that it currently has about 24% of the market for military rocket motors and chemical propellants. While this market will continue to grow, so will the competition for it. Consequently, Thiokol does not believe "that continued major growth can be achieved by increasing our share of this market."

Rather, the company feels that continued growth can best be achieved through diversification and product development in non-military markets. By 1964, Thiokol expects to push its non-military sales, now a small percentage of the total, to over $100 million or about one-third of total sales. To reach this goal, the company expects to obtain a major part of its scheduled commercial growth through acquisition and the rest from in-house developments.

Founded as a chemical company, Thiokol has continued to expand its activities in this field and as a result already has considerable commercial capability as a chemical producer and supplier. (Total sales of the Chemical Division in 1959, including sales to the rocket divisions, were $13,788,869.) In addition to Reaction Motors (which put the company into the liquid propellant field), Thiokol has acquired Hunter-Bristol (ordnance work, mechanical and plastic structures, shaped charges and auxiliary power units) and National Electronics Laboratories (communications, industrial instrumentation and control, and scientific instruments).

While Hunter-Bristol and National Electronics will contribute to Thiokol's military capabilities, they are also expected to play an important role in the scheduled expansion of commercial sales. In future acquisitions, Thiokol generally will be looking for companies engaged in related work that will be able to contribute to the growth of existing activities or extend Thiokol's ca-



Martin Develops Transportable Launcher for Mace

New steel launcher for USAF-Martin TM-76B Mace tactical missile weighs 5,700 lb. and is made of rectangular steel tubing. Launcher and missile are trailer-transportable. Mace rests in a 17 deg. nose-up position on a hinged arm which forms the front of the launcher. Arm is held upright on ball-shaped supports by locks which are explosively-actuated at actual launch. First launchings will be made at Cape Canaveral, Fla.

pabilities, increasing the market for their output or providing materials required for their operation.

One capability that Thiokol is interested in developing is its nuclear know-how. Thiokol had hoped to obtain some nuclear capability with the acquisition of Marquardt, until negotiations were called off after the two firms failed to agree on the terms of the acquisition. Now Thiokol management favors developing this in-house capability using what background already exists in the company's Reaction Motors Division and other groups, and toward this end has now established a separate nuclear division.

While diversification thus appears to be the dominant theme in the aviation industry's plans for survival and growth, it is not the only one. Two other factors, marketing and research, apparently are also destined to play an important part in these plans. In regard to the former, Thiokol again serves as a good example for much of the industry in that its plans typify current management thinking in many companies.

If Thiokol does not intend to increase its share of the missile market, then neither does it intend to let it diminish. But from here on in, it will take some hard selling, the company figures, just to keep the percentage at its present level. At a recent Thiokol gathering, Vice President Dr. Harold W. Ritchey illuminated this point when he said: "Up until now, we have been awarded contracts on the basis of our technical leadership. Today, technical leadership is not enough. You have to sell that leadership through advertising, public relations and all other marketing techniques that are used in selling any product or service."

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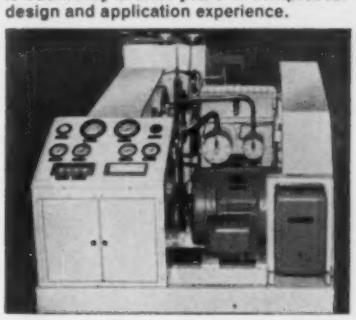

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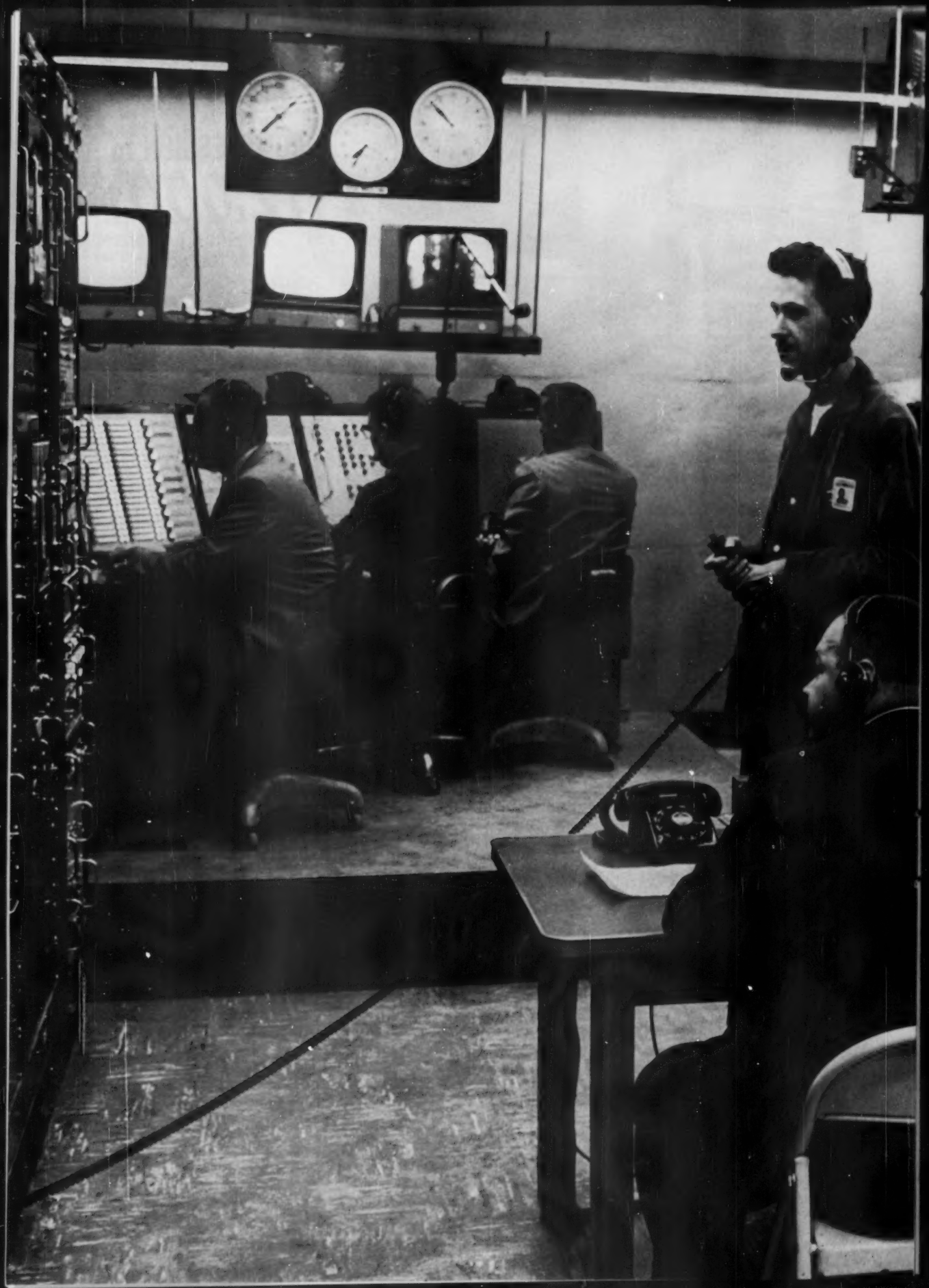

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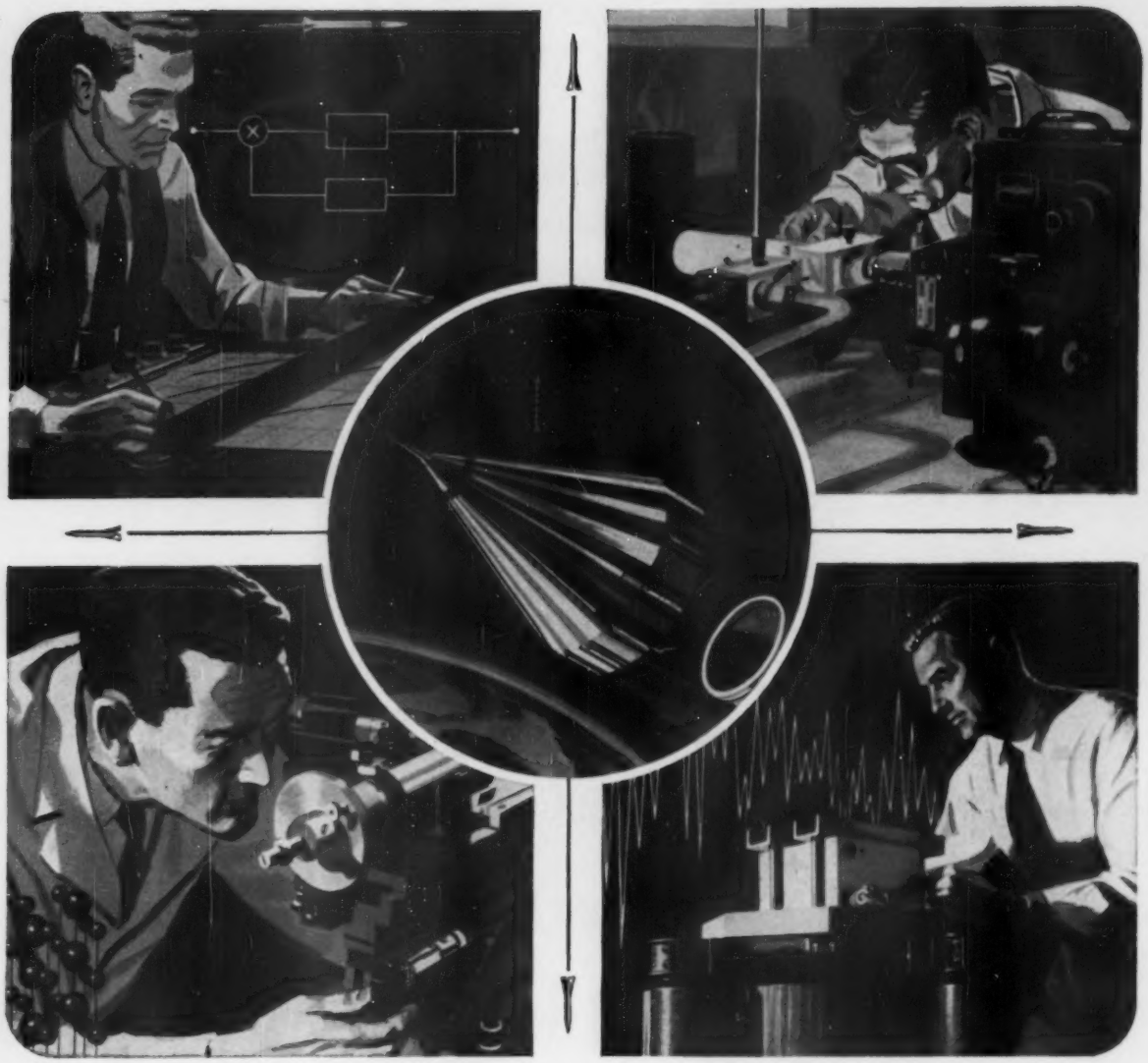

TASK FOR THE FUTURE

Since its inception nearly 23 years ago, the Jet Propulsion Laboratory has given the free world its first tactical guided missile system, its first earth satellite, and its first lunar probe.

In the future, under the direction of the National Aeronautics and Space Administration, pioneering on the space frontier will advance at an accelerated rate.

The preliminary instrument explorations that have already been made only seem to define how much there is yet to be learned. During the next few years, payloads will become larger, trajectories will become more precise, and distances covered will become greater. Inspections will be made of the moon and the planets and of the vast distances of interplanetary space; hard and soft landings will be made in preparation for the time when man at last sets foot on new worlds.

In this program, the task of JPL is to gather new information for a better understanding of the World and Universe.

"We do these things because of the unquenchable curiosity of Man. The scientist is continually asking himself questions and then setting out to find the answers. In the course of getting these answers, he has provided practical benefits to man that have sometimes surprised even the scientist.

"Who can tell what we will find when we get to the planets? Who, at this present time, can predict what potential benefits to man exist in this enterprise? No one can say with any accuracy what we will find as we fly farther away from the earth, first with instruments, then with man. It seems to me that we are obligated to do these things, as human beings."

DR. W. H. PICKERING, *Director, JPL*

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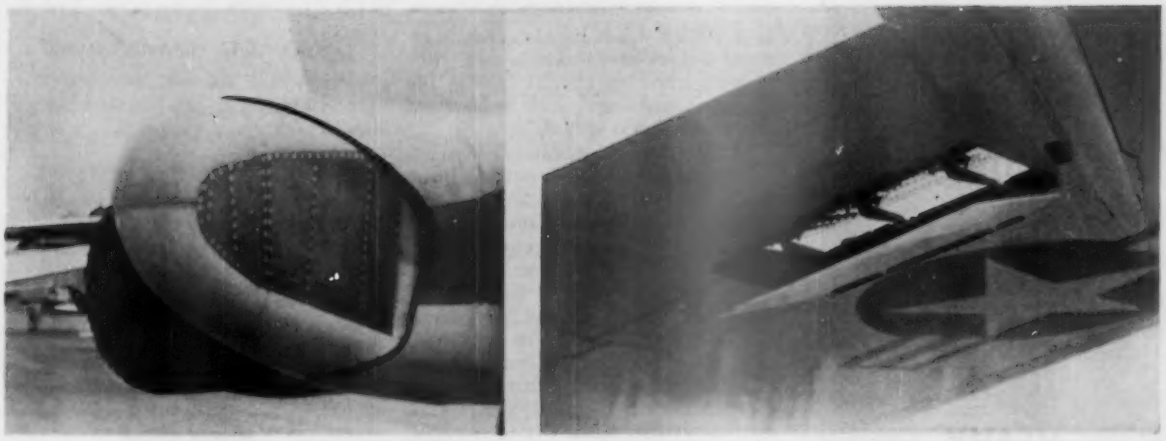


A3J Tail Cone, Speed Brake Details

Design features of North American A3J Vigilante attack aircraft include a disposable plug for aircraft's rearward delivery stores aperture (left). Plug is dropped in flight. Speed brake (right) in wing is unusual in that panels are raised on both upper and lower wing surfaces. The upper panel raises in the fashion of an airscoop and the flow passes through the open area and out the lower surface.

Thiokol, which already has strong and well coordinated advertising and public relations groups, recently created a new management position, director of marketing for rocket operations. The responsibilities of the person hired for this job, Robert Marquardt, are two-fold: First, he is to keep his fingers on the missile field's pulse to anticipate requirements. Then, when a requirement and prospective contract does occur, it is his job to recommend a corporate team, chosen from the different divisions, with the technical capabilities best suited to the particular job up for bid.

The payoff of the marketing function, says Ratheon's Peter J. Schenk, is sufficient sales of the right kind, at the right time and under the right conditions to meet a company's profit and other business objectives. Its importance in today's highly competitive aviation and missile market cannot be over-emphasized. In fact, Consultant Salvatore F. Divita declares, the marketing function must be accepted if the company is to continue to make a profit.

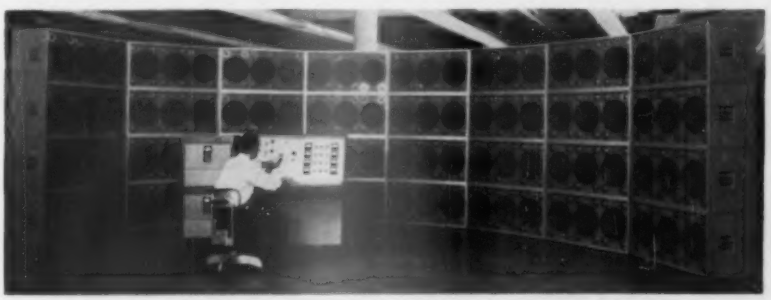
While more and more aircraft companies are establishing marketing groups, there are still many that fail to recognize the full significance of this function, say the management analysts. These are the companies which set up advance product planning groups but fail to service present contracts adequately or which emphasize market research but neglect sales and promotion. Others establish marketing groups but at a low level of administrative responsibility, and there are some companies which just have not bothered to create any marketing group at all.

Fundamentally, marketing embraces all aspects of a business from marketing research and product development to promotion, sales and service. But there is one segment of marketing that now appears to be taking on more significance than the others for those companies in the increasingly competitive aircraft and missile business, and that is customer orientation.

Among other things, this means learning the customer's needs. Actually, says one marketing analyst, this may entail learning what the customer thinks his needs are, and if these appear unrealistic, helping him recognize what his true needs are in light of military requirements, time schedules and available money. This in turn involves some educated crystal gazing and keeping abreast of continuously changing requirements.

An integral part of this customer orientation and education, of course, is showing him how your company is the one best suited to meeting his needs and then, says a marketing man, proving it by serving the customer with all capability at the corporation's command. It is the responsibility of the entire organization, says John Richardson of Hughes Aircraft, to serve the customer and to ensure that there is an effective synthesis of all the functions that go to make up modern marketing. Fulfillment of over-all corporate objectives, he adds, can be assured in no other way. Those companies that have continued to be successful in today's highly competitive defense market are the ones that have learned to think in terms of the customer's needs.

Heavy spending for research and development has become an accomplished fact in the aviation industry. Few any longer question the need for it. It is unpleasant—whether in the form of government contracts or com-



System to Test Sound Effect

High-intensity acoustical system, to be used by Wright Air Development Division to investigate physiological effects of high-intensity sound, is a Hi Fi enthusiast's dream. It includes 32 speaker systems, each consisting of three low-frequency "woofers" and 12 high-frequency "tweeters"—for a total of 480 speakers. Built by Stromberg-Carlson Division of General Dynamics, company says system has flat response between 20 and 20,000 cps., powered by either of two pairs of audio amplifiers. One pair has output of 200 watts, the other an output of 7,000 watts. Control console (center) provides four types of sound inputs: sine waves, white noise, tape recordings (or jet or rocket engine noise), or an external source.

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pany outlays, for it has significantly reduced the industry's earning rate. But it has become an integral part of the industry's new look, and the rate of R&D spending is still rising.

It is no longer a question of spending money on research in order to break into a new field or to get the jump on a competitor, declared an aircraft executive; now you have to spend all kinds of money just to stay where you are.

Owing to the research and development nature of the projects, the Martin Co. reports that 80% of its business is now in cost-plus-fixed-fee contracts, and it is generally expected that more and more of the defense work will be contracted on this basis. It is essential, says Martin, that defense contractors learn how to perform research and development contracts profitably if they are to maintain themselves in the forefront of high priority, advanced state-of-the-art programs. At the same time and for the same reasons, Martin has spent several million dollars of company funds on research, both basic and applied, and development.

United Aircraft is in much the same position. At present the company has approximately $200 million in sponsored engineering contracts. But the company could not develop relying on such contracts, says United Chairman H. M. Horner. Company-sponsored research and development is essential for growth, he feels, costly as it may prove. In 1959, United spent approximately $28 million of its own funds on research and development or about 2½ times the amount spent in 1958. At the same time, this spending is credited as "by far the most important factor" in the company's reduced net income for 1959 which was down approximately 32% from 1958.

Last year, Chance Vought increased its engineering and development expenditures 65% to the highest level in its history and expects this high level to continue through 1960. Burroughs Corp.'s expenditures on research and development in 1959 were up $2.7 million over 1958. Marquardt continued to increase its budget for company-sponsored research and development this year. In 1959, Lockheed charged $15 million to expense for research and development projects or 39 times the amount charged in 1949.

The story is much the same throughout the industry. In a year-end evaluation of the aerospace industry, Aerospace Industries Assn. President Orval Cook pointed out that in the 10 years following World War II, aerospace companies invested $1 billion of their earnings in research and development programs and facilities for aircraft and missiles and by 1961 this figure is expected to more than double.

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AMC Contracts

Wright-Patterson AFB, Ohio—Following is a list of unclassified contracts for $25,000 and over as released by the Air Materiel Command:

Westinghouse Electric Corp., Dayton, Ohio, panel, control, in accordance with Westinghouse specification D-627304(system specification), Mfg. P/N 905D942-2, FSN 4246-6110-519-2938, Aerno 42-0749, 51 ea.; component spare parts and maintenance tools and test equipment, use: spares for F-105D, (PR ES-C-6110-6713), $31,813.

Radiant Manufacturing Corp., Morton Grove, Ill., screen, projection, BM-6, type I, 96x96 in., 927 ea., and commercial literature, IFB-33-600-60-159(MIPR R60-32233-SC-24 and amendments 1 and 2), $39,619.

Marion Screw Products Co., Inc., Marion, Ind., SNR marking kit, photographic roll or cut film, type A-1 in accordance with specification MIL-M-4124A, (USAF) dated Sept. 25, 1959, 43 ea. and technical data, (Use: ground support equipment), IFB-33-600-60-160(PR MO-0-6780-12521 and amendment 1), $43,588.

Organic Chemicals Division, Monsanto Chemical Co., St. Louis, Mo., temperature stable hydraulic fluid, 150 gal., (PR 95774), $33,675.

Astronautics Corp. of America, Milwaukee, Wis., transmitter, thrust, single synchro style, pressure ratio, type Mk-2, contractor's P/N 1012, Aerno 61-2484, 117 ea., spare parts, ground support equipment and data, (Use: installation in and spaces for F-105 and F-106 aircraft), IFB 33-600-60-157(PR's EA-0-6620-6277 and amendments 1 and 2; SA-0-6620-C10183; ES-0-6620-6980), $131,000.

Simmonds Aerocessories, Inc., Tarrytown, N. Y., indicator set, liquid oxygen quantity type A/A24J-8, Aerno 46-1005, 50 ea.; indicator set, liquid oxygen quantity type A/A24J-4, Aerno 46-1004, 5 ea., engineering and technical data, (Usage: T-38A aircraft), IFB 33-600-60163(PR ES-0-6680-6596), $66,110.

Collins Radio Co., Cedar Rapids, Iowa, indicator, approach horizon, Collins type 329B-3, Aerno 60-1900, FSN 6610-557-0868, 17 ea.; indicators, course, Collins type 331A-3, Aerno 60-1901, FSN 6610-557-0867, 13 ea.; gyros, vertical, Collins type 332D-6, Aerno 60-1902, FSN 6615-553-4677, 25 ea.; gyros, monitor indicator, Collins type 327B-2, Aerno 60-1903, FSN 6610-625-1942, 16 ea.; computer, steering with shockmount, Collins type 562A-3B computer with 350M-1A shockmount, Aerno 60-1904, FSN 6610-600-1073, 17 ea., engineering data (components of MA-1 flight director systems), Use: spares for C-130B aircraft, (PR's ES-0-6610-6508; ES-0-6610-6509; ES-0-6610-6880; ES-0-6615-6881), $105,053.

Curtiss-Wright Corp., South Bend, Ind., preparing facilities for shipment, (PR BI-0-S-9010), $600,000.

Allison Division, General Motors Corp., Indianapolis, Ind., T56-A-7 turboprop engines, 83 ea. (2 ea., for Air Training Command; 2 ea., for spare support for SC-130B aircraft, USCG; 16 ea., for installation and 9 ea., for spare support of C-130B aircraft, USN; 28 ea., for installation and 28 ea., for spare support of GV-1 aircraft, USMC); T56-A-8 turboprop engines; 12 ea., for installation in W2F-1 aircraft, USN; T56-A-10W turboprop engines; 34 ea. (17 ea., for installation and 16 ea., for spare support of the P2V-1 aircraft and 1 ea., for training, USN), and related changes, (MIPR's R60-3926-35-NOas; R60-3923-27-NOas; R60-3924-32-NOas; PR's EP-0-2840-6186; EP-0-2840-6409; EP-0-2840-6410), $11,610,000.

Defense Electronics Products Division, Radio Corp. of America, Camden, N. J., relay assemblies, armament control, HAC part number 463057-130, FSN 1270-721-0161, 123 ea., for: MG-10, MG10T fire control system, (PR-9-1270-957), $155,768.

Fairchild Camera & Instrument Corp., Syosset, L. I., N. Y., spare parts for 0-15, 0-23 and K-17 aerial reconnaissance cameras, end use: B-47 and B-52 aircraft, (PR's MO-0-6710-12387 and MO-0-6720-12432), $32,179.

Aircraft Division, Parsons Corp., Traverse City, Mich., repair and modify droop snoot blades and conventional blades for HU-1A aircraft, (PR 92603), $28,787.

Bridge Electronics Co., Inc., Beverly, N. J., control panel, C-824A/AIC-10, Aerno 81-2309, 3,056 ea., End use: KC-135, T-37A and T-39A aircraft, (PR's EC-0-16A-6101; SA-9-5831-9432, MDO-5831-16073, 16108, 16108-1, 16072, 16131, 16126, 16198, 16223, and 16064; 00-9-6390-3687; MR-0-5831-3925, 4008, 4008-1, 4137, 4146; SA-9-16A-9436; MAO-1600-5831-117 and 117-1; ES-0-5831-6473; MIPR R59-1906-138-NOas), $399,518.

Instrument Division, Lear, Inc., Grand Rapids, Mich., absolute altitude and rate of climb indicators, (PR-63392), $42,813.

Pan American World Airways, Inc., New York City, CRAF Group B modification for FY 1960, (PR EM-0-8-6512), $54,055.

All American Engineering Co., Wilmington, Del., spare parts for aircraft arresting gear, (PR EM-9-RD-6323 and amendment 1), $44,075.

Continental Aviation & Engineering Corp., Detroit, Mich., J69-T-29 turbojet engines in accordance with contractor's specification 2157A as revised Jan. 20, 1959 and installation drawing 576776, 108 ea., use: installation and spares for Ryan Q2C target drone, (PR's EP-0-2840-6134 and amendment 1; EP-0-2840-6547), $1,576,800.

General Electric Co., West Lynn, Mass., indicators, rate of flow, type EFU-4/A, FSC 6119-6620-621-2903, contractor's P/N 8DJ71GAK-2, Aerno 61-2493, 673 ea., for installation and retrofit for B-52 aircraft; indicators, rate of flow, type EFU-4/A, FSC 6119-6620-621-2904, contractor's P/N 8DJ 2GAD-2, Aerno 61-2494, 85 ea., for installation and retrofit, B-52 and QEC kits; transmitters, rate of flow, type TRU-7/A, FSC 6119-6620-621-2902, contractor's P/N 8TJ 50GBM-5, Aerno 61-2495, 1,018 ea., for installation and retrofit for B-52 and KC-135 aircraft, and data, (PR's OC-9-01F-B52-13863; ES-0-6620-6237 and amendments; ES-0-6620-6237 and amendment 1; ES-0-

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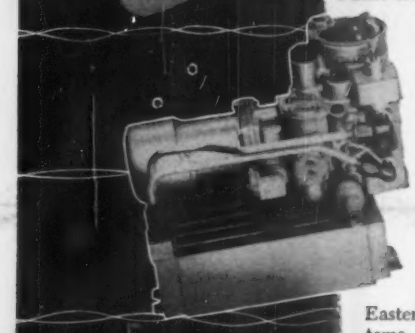

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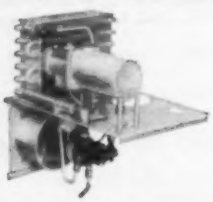

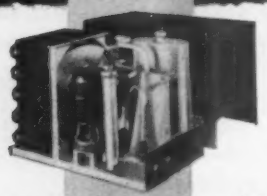

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6620-6238 and amendment 1; WS-0-6620-6239 and amendment 1), $760,000.

Defense Electronics Products Division, Radio Corp. of America, Camden, N. J., data link receiving sets (AN/ARR-61) and supporting test equipment and maintenance spare parts, end use: F-106 aircraft, (PR ES-0-5821-6585), $784,000.

Federal Systems Division, International Business Machines Corp., Oswego, N. Y., spare components of AN/ASB-4 and AN/ASB-9 bombing navigational systems (used on B-52 aircraft), (PR WR-60-11A-1032 and WR-60-1280-4681 and amendment 1), $450,000.

Friez Instrument Division, Bendix Aviation Corp., Towson, Md., radiosonde sets, type AN/AMT-13(XH-1), 200 ea.; receiving sets, radiosonde, type AN/AMR-4 (XH-1), 3 ea.; dispensing sets, radiosonde, type AN/AME-3(XH-1), 3 ea., spare parts, special tools and test equipment, handbooks, drawings and data, (PR EC-9-ST-4528), $408,948.

Sperry Phoenix Division, Sperry Rand Corp., Phoenix, Ariz., E-4 automatic pilot components for C-130B aircraft and data, (PR ES-0-6615-6548), $253,948.

Leland Airborne Products Division, American Machine & Foundry Co., Vandalia, Ohio, inverters, 250 VA, three or single phase, class A, type MS-25 73-1, Aerno 42,2318, 243 ea. (for Army support of HU-1A aircraft), IFB 33-600-60-123(PR ES-0-6514), $94,595.

Summers Gyroscope Co., Santa Monica, Calif., design, fabrication and testing of instantaneous vertical velocity indicator systems, 3 ea., and technical data and reports (for B52, F-101, KC-135, C-133, C-130 and B-58), (PR EA-9-ST-4864), $94,575.

Norair Division, Northrop Corp., Hawthorne, Calif., storage, supply and maintenance of spares and equipment in accordance with NORAIR report number 8833-475 dated Nov. 18, 1959 (for the T-38 aircraft), (PR TR-0-1510-5061), $153,955.

Kollsman Instrument Corp., Elmhurst, N. Y., engineering services to support installations and test of MD-1 compass for B-52 aircraft, (PR EG-0-S-6635), $26,826.

Westinghouse Electric Corp., Dayton, Ohio, generators, a.c., for aircraft, 40 kva., Westinghouse P/N 904J019-2, FSN 4246-6115-678-6305, Aerno 42-0331, 162 ea., spare parts, ground support equipment and maintenance data, (for KC-135A aircraft), (PR's ES-0-6115-6547; ES-0-6115-6579; ES-0-6115-6837), $177,720.

Lockheed Aircraft Corp., Marietta, Ga., C-130B aircraft, (PR TK-0-1510-5080), $3,500,000.

General Electric Co., West Lynn, Mass., indicators, rate of flow, fuel, totalizing, type MA-7, FSN 6119-6620-551-2631, 127 ea. (USN installations); indicators, rate of flow, totalizing, fuel, type MA-8, FSN 6119-6620-551-1270, Aerno 61-2464, 43 ea., (USAF installations), aircraft usage; C-130B, (PR's ES-0-6620-6456; ES-0-6620-6432; ES-0-6620-6365; EA-0-6620-6265; MIPR R60-4374-92-NOas), $77,789.

A. Quincy Jones-Frederick E. Emmons & Assoc., Los Angeles, Calif., architectural and engineering services, (PR PD-9-S-1099), $28,418.

Bell Aircraft Corp., Buffalo, N. Y., procurement and development of management simulation techniques, (PR 85575), $96,591.

Weber Aircraft Corp., Burbank, Calif., aft-facing passenger seats, (PR 96073), $29,811.

The Goodyear Tire & Rubber Co., Akron, Ohio, wheel assemblies, main, type VII, 26x6.6, Aerno 41-7380, 97 ea.; brake assemblies, for above wheel, type VII, Aerno 41-7381, spare parts and data for T-39 aircraft, (PR's ES-0-1630-6516; ES-0-1630-6517; ES-0-1630-6542; ES-0-1630-6543; ES-0-1630-6592; ES-0-1630-6593), $30,400.

Boeing Airplane Co., Seattle, Wash., modernization facilities for Bomarc program, (PR BI-0-F-90855), $170,450.

Melpar, Inc., Falls Church, Va., broadband radiator program (for use with radio interference generator set AN/GRM-8 (XA-1), (PR 86702), $65,256.

Solar Aircraft Co., San Diego, Calif., power units, turbine, airborne, Aerno 43-2348, 75 ea., maintenance and engineering data, usage: installation in KC-135, (PR's EA-0-02B-6014 and amendments 1, 2, & 3 and ES-0-2835-6296), $2,214,393.

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Get more information

about products and services advertised

Now, one of these handy prepaid postcards will bring you more information on

Products
Components
Materials
Services

How to use the card

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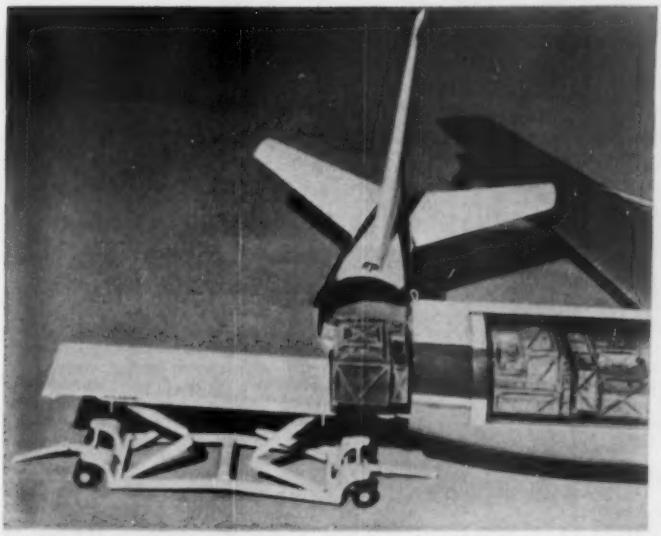
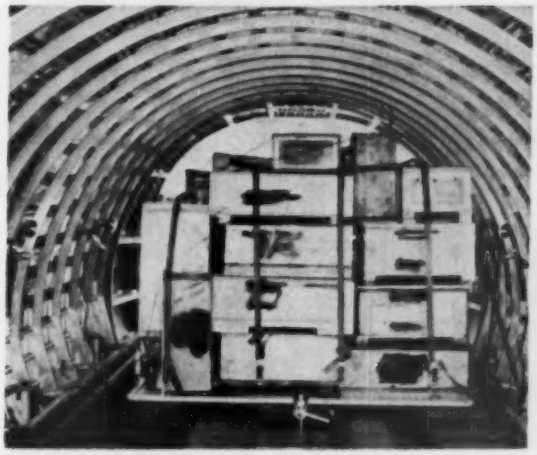




MODEL of Boeing's 735 all-cargo jet (above) shows swing tail loading and adjustable height transporter Boeing is designing for ground handling. Mockup of the 735 (below) shows fuselage interior cargo handling. Standard high lift trucks (right) can be used.

Boeing Reports Analyze Air Cargo Needs

By Russell Hawkes

Renton, Wash.—The bright potential of air cargo may never be realized if government and industry fail to exploit cost and rate reduction opportunities offered by advancing technology.

This warning qualifies the optimistic outlook of a five-year series of market analyses that is the core of the air cargo philosophy under which Boeing Airplane Co. is developing its swing-tail Model 735 cargo jet for commercial carriers and Military Air Transport Service.

The analyses, made for Boeing by Stanley H. Brewer of the University of Washington, point out that the many predictions of an air cargo boom are based upon the fact that in a time of rising transportation costs, air carriers alone are offered important cost cutting opportunities by advances in vehicle design. In the past, airlines have hesitated to invest in modern aircraft for cargo operations and Civil Aeronautics Board has not allowed rate minima to reflect their cost advantages. If this pattern is repeated, the predicted boom will fail to materialize like other air cargo booms predicted since World War II. One study reports that:

"Although the Civil Aeronautics Board has given the air carriers substantial latitude insofar as the ceiling for air freight rates is concerned, it adopted a protective attitude in setting minimum rates.

". . . Our national policy has been to tie minimum air freight rates to what the Board called "attainable costs" of operation of the least efficient aircraft. This economic felony is further compounded when the all-cargo carriers lease or charter their more modern aircraft, leaving only the older outmoded equipment in the rate-protected domestic air cargo market.

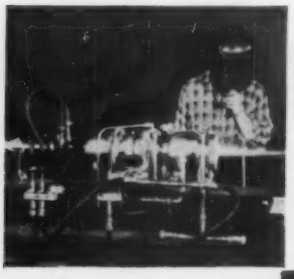
"The rate cannot and will not come down as long as this kind of equipment is dominant in air cargo transportation and as long as the Civil Aeronautics Board insists on minimum rates that will cover out-of-pocket costs for operating these airplanes.

"Freight is the stepchild of the passenger carriers. Air freight transporta-

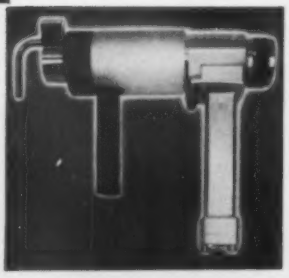
LOOK TO AVCO...
for use-proven space age research tools

Now available from Avco are advanced products and systems in the fields of Hypervelocity Instrumentation, Rocket-Environment Test Equipment, and Plasma Research Facilities. Represented by local agents throughout the United States and the world, these products are fully use-proven in research and development laboratories across the nation.

PLASMA RESEARCH FACILITIES

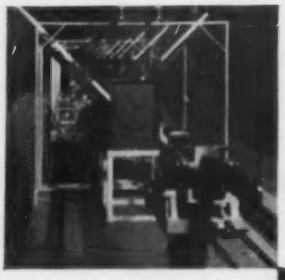


Plasma Generator PG-500, operating with air as the working fluid, duplicates all essential conditions of atmospheric re-entry, consumes up to 1.5 megawatts of power, produces enthalpies up to 12,500 Btu/lb. Uses include plasma research, materials testing and re-entry simulation.

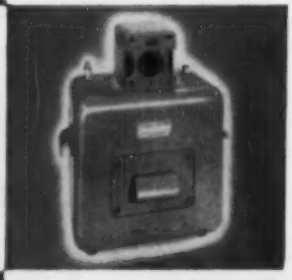


Plasma Generator PG-030, designed as ultra-reliable powder spray tool for industrial applications and as laboratory heat source for scientific applications, consumes from 4 to 50 KW of power, sprays tungsten, carbides, alumina, zirconia, etc. Available with pistol grip or pedestal.

HYPERVELOCITY INSTRUMENTATION

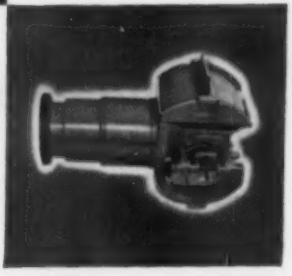


Shadowgraph and Schlieren Systems record events associated with hypervelocity aerodynamic phenomena; include light source, lenses, catadioptric light screen, Kerr Cell Shutter and Camera. Record shock waves, flow patterns and impact deformations of space age research.



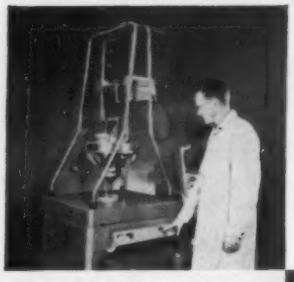
Avco Kerr Cell Shutter permits any exposure from .005 to .1 μsec., is available as an independent module. Large 2-inch aperture unit may be remotely positioned for maximum utility. Useful for ultra-high speed shuttering in ballistic, chemical and thermal research. Can be synchronized to Package Light Source.

Package Light Sources, providing from .3 to 1 μsec. light pulse durations, are general purpose, spark-type units of cylindrical construction with coaxial discharge path; predetermined triggering; also provide synchronized output pulse for balance of system.

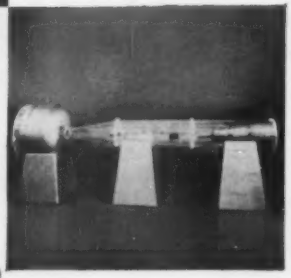


Rotating Mirror and Drum Cameras for accurate position-versus-time recording of hypervelocity events. Mirror camera writes at rate of 4mm/μsec. on 70 mm film; Rotating Drum Camera writes at rate of .19 mm/μsec. on 76mm film for streak and Schlieren recording.

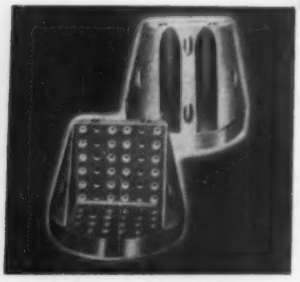
ENVIRONMENTAL TEST EQUIPMENT



Shock Machines, 100 and 500-lb. capacity machines with shock pulses up to 1500 g's, meet ballistic missile test specifications by providing saw-tooth, quarter- and half-sine, and triangular pulses. 20-lb. capacity machine available June, 1960.



Acoustic Noise Test Systems available in a variety of configurations to meet specialized requirements. Systems available with random noise outputs of 163, 150, 140, and 120 db. Larger systems feature Avco Acoustic Noise Generator AG-012, simulating random noise of rocket engine firing.



Environmental Test Fixture TF-006-1 is compact and versatile, virtually resonance-free up to 2000 cps, mounts on standard vibration exciters, centrifuges and shock machines; also handles several specimens along three mutually perpendicular axes.

Avco

Research & Advanced Development division

For more information write: Products and Services Department, Research and Advanced Development Division, Avco Corporation, Wilmington, Massachusetts.

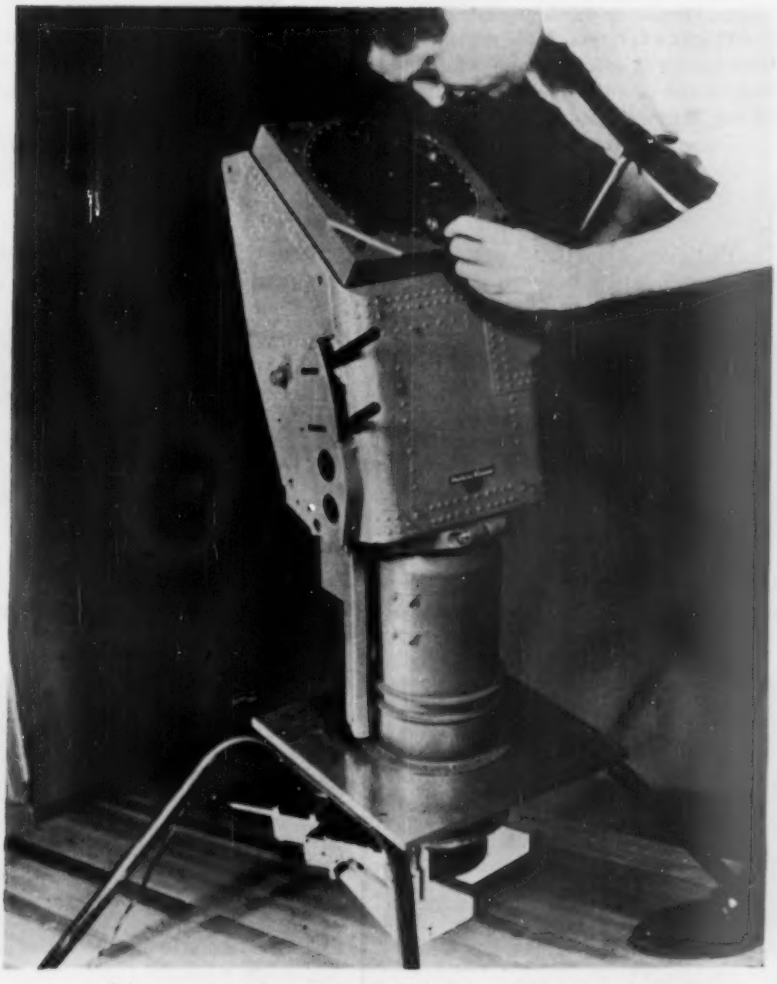
Circle Number 320 on Reader-Service Card

tion is not given major consideration in management thinking in this industry. As long as this attitude prevails, the older equipment of the trunkline carriers is the only kind that will be relegated to all-cargo schedules. Very few new aircraft have been purchased by the passenger operators for the purpose of moving freight. Most of the freight carried by these companies is moved in the baggage compartments of passenger planes."

Despite these warnings, Brewer and Boeing officials are betting that the boom will materialize. In a recent analysis of military air cargo requirements, Brewer and Roger B. Ulvestad of UCLA noted that the need for speed in defense transportation can be so great as to make economic arguments superfluous. If Boeing can win military orders for the swing-tail 735, it will smooth the path to commercial business by absorbing some of the development costs, permitting a lower price and earlier delivery to civilian buyers. Boeing officials are convinced that the airplane itself will generate the rest of the conditions necessary to a great air cargo expansion if enough orders are received to justify building it.

Though Douglas and Convair, as well as Boeing, are offering cargo versions of their passenger jet transports, designers will admit that the ideal cargo jet should be designed from the wheels up for cargo service rather than being converted from a passenger design.

The reasons for not doing it are economic rather than technical. There is simply not enough money available to pay for the design of a completely new large airplane. Military appropriations are too small and passenger



Mercury Capsule Periscope Delivered

Periscope for manned Project Mercury space capsule goes through final optical check at Perkin-Elmer before shipment to prime contractor, McDonnell Aircraft. Objective lens cartridge of periscope will extend and retract through the skin of the capsule. On 8-in. diameter display area atop periscope, astronaut will have 180-deg. view of earth with center 20 deg. magnified for greater detail.

BRANSON ULTRASONICS

for efficient, economical

Cleaning • Gaging • Flaw Detection

Branson-engineered Ultrasonic Equipment offers **ECONOMY** based on standard designs adaptable to individual requirements — **DEPENDABILITY** of simple, rugged designs — **SERVICE** by factory-trained specialists available at all times.

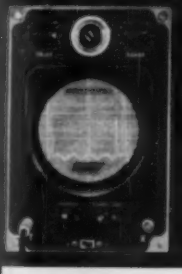
ULTRASONIC CLEANING

SONOCEN®

Intense 38-kc cleaning power, proven designs, in units from laboratory size to the largest engineered, conveyorized installations. Assures micro-cleaning of delicate parts and large complex castings, rods, tubes, machined and lapped parts, etc. Multi-stage systems for batch and continuous work flow. **Bulletin S-200.**

GAGING & FLAW DETECTION

VIDIGAGE® direct-reading resonance-type thickness gages: 0.005" to 2.7", accuracies to 1/10 of 1%. **Bulletin V-200.** Also **AUDIGAGE®** portable self-powered testers, **Bulletin A-2.**



SONORAY® pulse-echo type Flaw Detector for contact or immersed testing in shop or field. Weighs only 35#. Great versatility, sensitivity and resolving power in a compact, portable, economical instrument. **Bulletin T-203.**

Send Coupon to **BRANSON ULTRASONIC CORPORATION**
16 Brown House Road, Stamford, Connecticut

BRANSON: Send Bulletins — S-200, V-200, A-2, T-203

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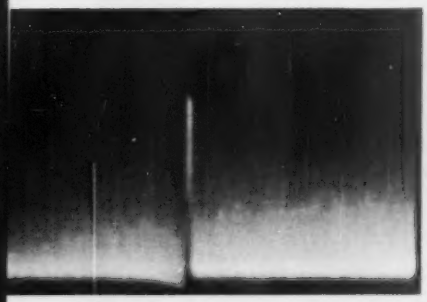
The logical connection between

Little Susie at the beach when projected on a home movie screen will appear sharp and clear. That's because she will be seen not in a single picture, but in 16 of them every second. Amidst the "random noise" in a tiny 8mm movie frame, little non-random Susie will stand out sharp and clear.

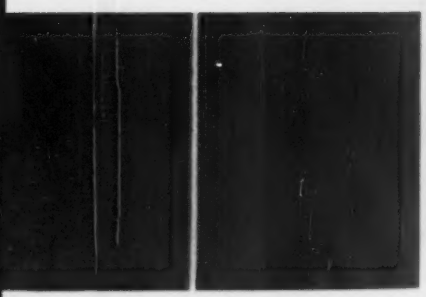
This is a very important principle about photography, the eye, and the brain. We have extended it out to a horizon beyond little Susie on the beach, out to where the problem really gets difficult—at sea, for example, when it takes the form, "Is there something down there?"

These pictures illustrate what we mean. They are an example of photography's great talent for finding the signal amid the noise and passing it on to the brain.

1 Instead of an ordinary A-scope trace like this . . .

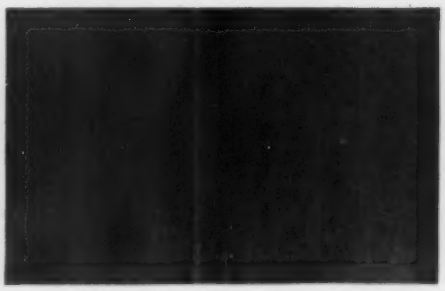


let's modulate intensity and sweep over moving film with much overlap . . .

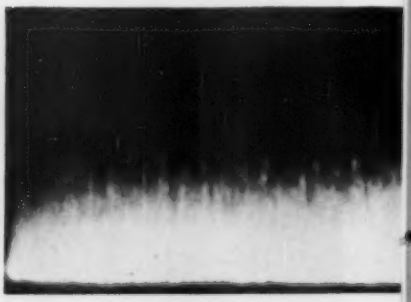


2 so that even when the significant pulse stands out from the noise no more than this . . .

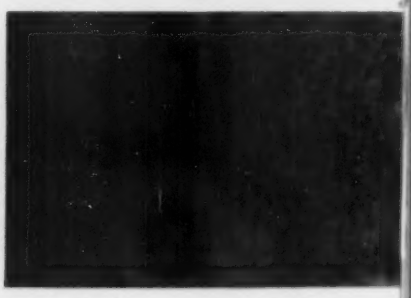
photographic summing-up finds it rather easily;



3 even when the A-scope shows only this . . .



the weak but non-random blip holds position and builds up from all the sweeps to where the marvelous combination of photography and the human perceptive mechanism says, *"There!"*



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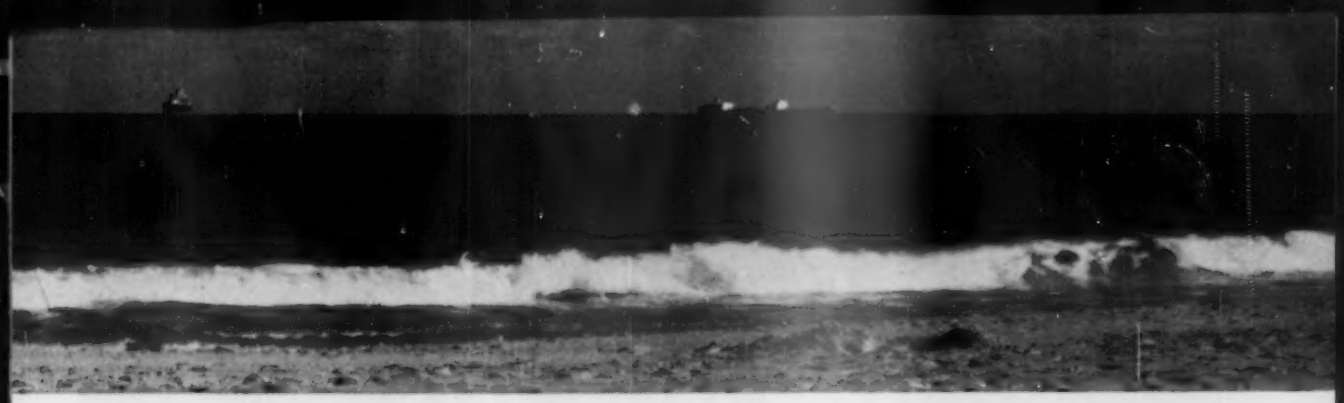
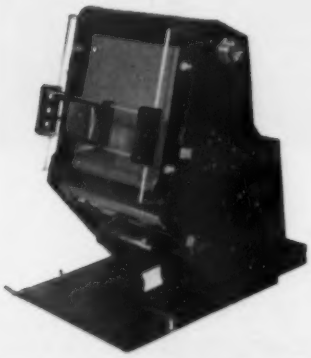


Kodak and anti-submarine warfare



"Photography" in connotations like the foregoing has nothing to do with waiting outside a darkroom door for a man to emerge with the picture. Kodak today is making equipment like this Recorder-Rapid Processor-Viewer which speeds up the photographic process to display a meaningful nadir-to-horizon view from a side-looking radar *only 10 seconds behind the scan.*

It's a great success, and we'll be happy to build as many of them as needed. This, however, is less an advertisement for the Kodak Recorder-Rapid Processor-Viewer than for the *force in being* which created it.

These men brought together the chemistry, the chemical engineering, the mechanical engineering, the electronics, the psychophysics, the optics, the understanding of the potential of light-sensing emulsions.

Whether by acoustics or other forms of energy propagation, whether by infrared or other regions of the electromagnetic spectrum, what the sensing systems pick up lacks meaning until a signal is separated from the noise and presented to a man's mind for decision. In this vital part of the ASW problem, Kodak is currently contributing to several projects and can take on more.

Shall we meet and talk
of the connection between our capabilities and your problems?

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EASTMAN KODAK COMPANY, *Apparatus and Optical Division,* Rochester 4, N.Y.

The Civil Avon has been in service since October 1958. In under eighteen months the overhaul life was increased from 1,000 hours to 1,800 hours in the De Havilland Comets of British Overseas Airways Corporation. Civil Avons entered service at a rating of 10,250 lb. thrust for take-off. Engines now in production for the Sud-Aviation Caravelle give 11,400 lb. thrust, and later versions of the Avon will give 12,725 lb. thrust.

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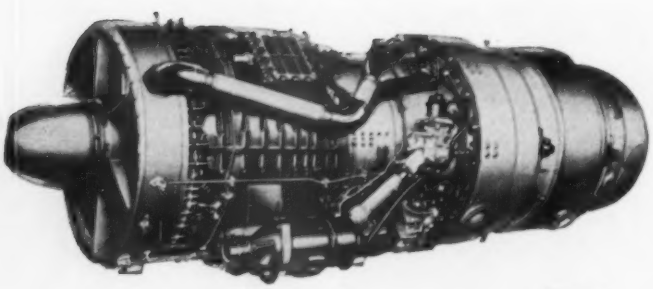

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jets have soaked up most of the airline money that might have gone for totally new cargo airplanes. To wait for enough money to accumulate would involve an indefinite postponement of the planned expansion.

The Boeing analyses indicate that the swing-tail redesigns will be more than adequate economically. They show that the 735 with a speed of 600 mph. and a payload of 100,000 lb. at a nonstop range of 3,000 mi. will have direct operating costs per ton-mile even lower than those of the turboprop Douglas C-133B, currently the most economical cargo carrier in the MATS inventory, with direct operating costs 75% those of the next best airplane. Boeing claims that more than 90% of major airports along high potential cargo routes will accommodate the 735. It has a maximum gross weight of 316,000 lb. and will be powered by four Pratt & Whitney JT3D turbofan engines developing between 10% and 15% more power than the basic JT3C or J57.

A study of the directions in which potential air cargo flows reveals a negative factor. To qualify as a candidate for air movement, a cargo must have high value per pound to justify the higher air rates. An average value of a dollar per pound definitely establishes a commodity as an air prospect and many with lower values can also move by air profitably. In domestic trade, most of the qualifying products are manufactured in the industrial northeastern and north central parts of the country for shipment to the south and west.

Lack of cargo moving north and east poses a perplexing problem. As a Boeing study observed, "a 100% load factor in one direction and 50% on the return trip averages only 75%. Not too many carriers can do that well."

The lower direct operating costs per ton-mile of cargo jets, such as the Boeing 735, should tend to remedy this, since they should increase the flow of lower value goods more than that of high-value goods which already move by air.

Analysts have noted that air cargo probably will never be a large percentage of the total freight movement by all modes. The potential has been estimated at from 1% to 4% of the total. The present air cargo traffic is only a small fraction of 1%. To some extent, the speed of aircraft is capable of generating new markets by carrying things which would never move otherwise. Typical is the long-distance cut flower traffic which is an important part of existing air cargo and could not be served as well at this time by any other type of carrier. But the biggest growth is to be had by penetrating markets now served by surface vehicles. This can be done only if air rates are brought down

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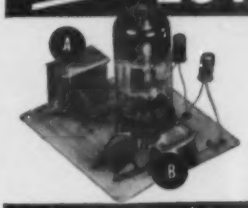

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Permit positioning foil-wrapped components A & B closely, minimizing interaction due to magnetic fields . . . making possible compact and less costly systems.

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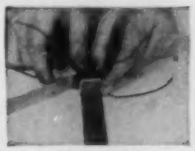
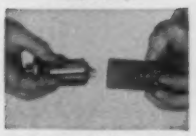


Wraps easily.



Inserts readily to convert existing non-shielding enclosures.

Shielding cables reduces magnetic radiation or pickup.

Wrapping tubes prevents outside magnetic interference.

How thin Co-Netic and Netic foils lower your magnetic shielding costs:

1) Weight reduction. Less shielding material is used because foils (a) are only .004" thick and (b) cut and contour easily.

2) Odd shaped and hard-to-get-at components are readily shielded, saving valuable time, minimizing tooling costs.

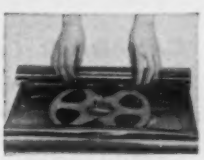
These foils are non-shock sensitive, non-retentive, require no periodic annealing. When grounded, they effectively shield electrostatic and magnetic fields over a wide range of intensities. Both foils available from stock in any desired length in various widths.

Co-Netic and Netic foils are successfully solving many types of electronic circuitry magnetic shielding problems for commercial, military and laboratory applications. These foils can be your short cut in solving magnetic problems.

PROTECT VITAL MAGNETIC TAPES

When accidentally exposed to unpredictable magnetic fields, presto!—your valuable data is combined with confusing signals or even erased.

For complete, distortion-free protection of valuable magnetic tapes during transportation or storage. Single or multiple reel Rigid Netic Enclosures available in many convenient sizes and shapes.



Thin pliable foil wraps easily around magnetic tape, maintaining original recorded fidelity.

Rigid Netic (.014" and up in thickness) Shielded Rooms and Enclosures for safe, distortion-free storage of large quantities of recorded magnetic tapes.

Composite photo to demonstrating that magnetic shielding qualities of Rigid Netic Alloy Material are not significantly affected by vibration, shock (including dropping or bumping) etc. Netic is non-retentive, requires no periodic annealing.

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YOUR piston powered passenger carrying aircraft now rendered obsolete by new equipment, and being considered for use in cargo operations, or already actually converted can be completely removed from fleet inventory and written down to zero book value in three years;

ONE THIRD the number of Canadair Forty Fours will carry out your cargo requirements at such a profit that they will absorb all expenses incurred in the retirement transaction, plus any earnings your piston engine aircraft would have realized during these three years;

AFTER THESE THREE YEARS, the Forty Four operating profit curve will climb steeply. The difference in profit potential for the following years is substantial.

Any consideration of a specific example requires certain assumptions regarding scheduling, future rates, and load factors, but, under a representative set of conditions our analysis indicates:—that a fleet of 25 piston powered aircraft currently being converted into cargo carriers, could be replaced and retired by a fleet of 8 Forty Fours. The above assumptions and statements are based on the unlikely premise that cargo rates will remain at present levels. If they are reduced, as seems inevitable, the situation will favor the Forty Four even more strongly.

THE FORTY FOUR. The Canadair Forty Four, with its combination of low direct operating costs, high block speeds and large payload capacity, is the world's most economical cargo aircraft. Delivery schedules can be arranged to introduce the Forty Four into airline service fourteen months from contract agreement.

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closer to surface vehicles. This can be done only if air rates are brought down closer to surface rates.

A problem which must be overcome by air carrier sales staffs is the tendency of small shippers, lacking trained traffic managers, to rely on average rate figures in picking their modes of transportation. The shipper learns that the average ton-mile rates for air freight are generally 10 times as high as rail rates and almost four times as high as truck, and comes to think of air freight as an emergency mode to be used rarely. One flaw in this reasoning is that air mileage between pairs of cities averages 26.36% less than rail mileage and 20.42% less than highway mileage.

Even more important is the effect speed has upon the total cost of producing, shipping, storing and selling a product. Under the total cost concept, the cost of carriage should not be segregated from the costs of damage and pilferage in transit which are characteristically higher for surface forms of transport because of the larger number of handling cycles involved. It also includes the idea that the lower speed of surface transport means the consignee must store a larger inventory to be prepared for peak demands, thus tying up capital, incurring the costs of warehousing, and increasing the risk of obsolescence and depreciation.

The volume of U.S. international air cargo has quadrupled in the past 10 years and increased by a factor of 12 since the end of World War II, but Boeing studies indicate the present level is only .01% of total U.S. import and export cargoes by all modes. The rest goes by ship. Boeing experts calculate the air cargo slice should be 10 to 20 times greater.

However, aviation will not get its proper share unless the rates can be brought down. Rate reduction will be possible if airline operating costs are cut. The present air cargo rates of over 20 cents per ton-mile are based on direct operating costs of 7 cents per ton-mile for present piston-engine aircraft. Boeing estimates direct operating costs for the Model 735 at 3 cents per ton-mile. If indirect operating costs can be held in the same proportion of about one-half direct costs as now, it would seem possible to cut rates to 10 cents.

Boeing and everyone else connected with air cargo is giving much thought to the problem of bringing indirect costs down with direct costs. To some extent, increased traffic caused by lower rates will do this automatically by spreading some of the fixed costs over a greater number of ton-miles. Boeing is also working on improved terminal equipment to improve productivity of ground personnel and cut the turnaround time of aircraft. One piece of equipment being designed is a cargo transporter with a mechanical lift to set the cargo platform at the height of the aircraft deck, the loading dock or truck beds. Detail engineering on the transporter has not yet been done, but some such device is needed because of the high deck of the 735.

Most designers would prefer to build cargo aircraft with decks at truck bed height, but this would call for a new and expensive design and would delay jet cargo service indefinitely. The lower cargo lobe is likely to be loaded with pre-loaded cargo containers.

Boeing estimates the 3,000-mi. range of the 735 will handle every medium-to-long haul trade route profitably. Its maximum gross weight is to be 316,000 lb.

Boeing concedes that the economic advantages of the 735 are limited at low load factors and short ranges. Also, its weight-density ratio is higher than many cargo aircraft, so it is best suited to dense cargo. This is typical of aircraft originally designed as passenger carriers and then redesigned for cargo. With low-density cargo, it increases the possibility that the internal volume of the airplane will be filled before maximum payload has been put aboard—that is, its cargo load will be space-limited rather than weight-limited. The 735 is to have an internal volume of 8,483 cu. ft.

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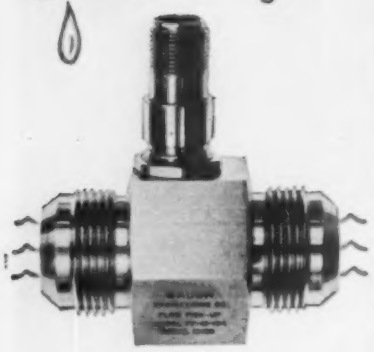

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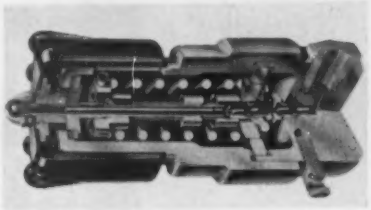


Pressure Regulator

Small volume, high pressure regulator for missiles and space vehicles performs pneumatic, hydraulic and fuel transfer functions.

Internal parts shown in cutaway view include relief screw, guide, operating spring, diaphragm, special filter unit, nylon valve and stainless steel seat. A single screw adjusts the dead range, or sensitivity range of the downstream relief function. Regulators are available in ¼ and ⅜ in. sizes, inlet pressure capacity range to 10,000 psi and for controlled or reduced pressures to a maximum of 6,000 psi.

Grove Valve and Regulator Co., 6529 Hollis St., Oakland, Calif.

Aircraft Air Conditioner

Mobile air conditioner is designed for ground service on small and medium size aircraft and military fighters.

The Model H-10 ground unit, with a 10-ton refrigeration capacity, is a smaller version of a 35-ton model for large transport aircraft. Primary power for the air conditioner is a gasoline engine. The unit is light enough to be positioned by one man.

C. G. Hokanson Co., Inc., 2140 Pontius Ave., Los Angeles, Calif.

Pressure Sensing Bellows

Metal bellows for pressure and temperature sensing devices operates at temperatures to 1,200F and at pressure to 12,000 psi. Major application for the bellows is on jet engine fuel metering devices.

The Omega design bellows is available in aluminum, Inconel-X, monel, stainless steel and beryllium copper; in sizes from ¼ to 1¼ in. outside diameter. Lengths up to 18 in. are available in standard production with larger sizes to order.

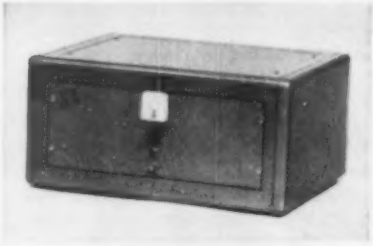
B. F. Goodrich Aviation Products, B. F. Goodrich Co., Akron, Ohio.

Engine Bleed Valve

In-line valve is designed to handle engine bleed air at 450F and 75 psig. Original application is to de-ice the front frame of the Lycoming T55 turbine engine.

The poppet type valve weighs 14 oz. and will operate in ambient temperatures from −65 to plus 300F from sea level to 40,000 ft. Current draw is 1 amp. or less at 24 vdc. and 70F.

Vap-Air Division, Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.



Runway Light Actuator

Airborne actuating unit permits pilots to turn on runway lights for a 15 min. period. Airport lights will be turned on upon receipt of coded pulse signal found in the Airman's Guide.

Transmitting unit, called Nyte-Flyte, operates in conjunction with a receiving runway actuator. Upon receipt of coded signal, the lights will be turned on for 15 min. Prior to being turned off, the lights will be flashed to warn any pilot making an approach. Receipt of a second pulse signal will extend the

lighting period 15 min. An optional fail-safe circuit keeps the lights on in the event of malfunction.

Electro Mechanical Engineering Co., 2449 Gardena Ave., Signal Hill, Calif.

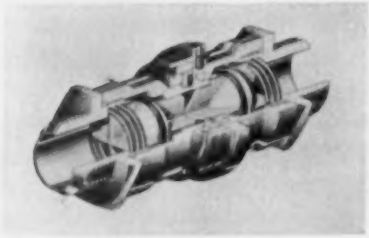
Hydraulic Servo Valves

Flight control tandem servo valves and actuators have a one-piece sleeve and one-piece spool machined to reproduce identical flow characteristics in two separate hydraulic systems.

Model HP324100 and HP325100,

constructed in one piece, retain factory set synchronization. The servo valve, with rectangular orifices, has true linear flow. The units are designed for 4,000 psi, 275F hydraulic systems.

Hydra-Power Corp., Pine Court, New Rochelle, N. Y.



Fluid Coupling

Quick-connect fluid coupling for missile umbilical and hydraulic test applications handles fluids ranging from air to cryogenic liquids.

Re to Lock couplings will be available in standard sizes from ¼ to 3 in. with larger sizes available on special order. Coupling materials include aluminum, stainless steel, carbon steel and plastic. The coupling, consisting of a locking pin mechanism, star poppets and an indicating mechanism, minimize pressure drop in the fluid line.

New Products Dept., Jack & Heintz, Inc., 17600 Broadway, Cleveland, Ohio.

Flameout Detector

Detector automatically turns on ignition for an immediate relight in the event of a flamout. The device is designed to provide the same restart results as continuous ignition.

The thermostatic switch located in the turbine exhaust stream remains open at temperatures between 1,200 and 400F. Below 400F the switch is closed. Any sudden temperature drop

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Contributing to the Vertol 107's across-the-board versatility is its large, unrestricted cargo capacity and straight-in rear ramp loading, which permit loads to be transported internally, externally, or half-in, half-out.

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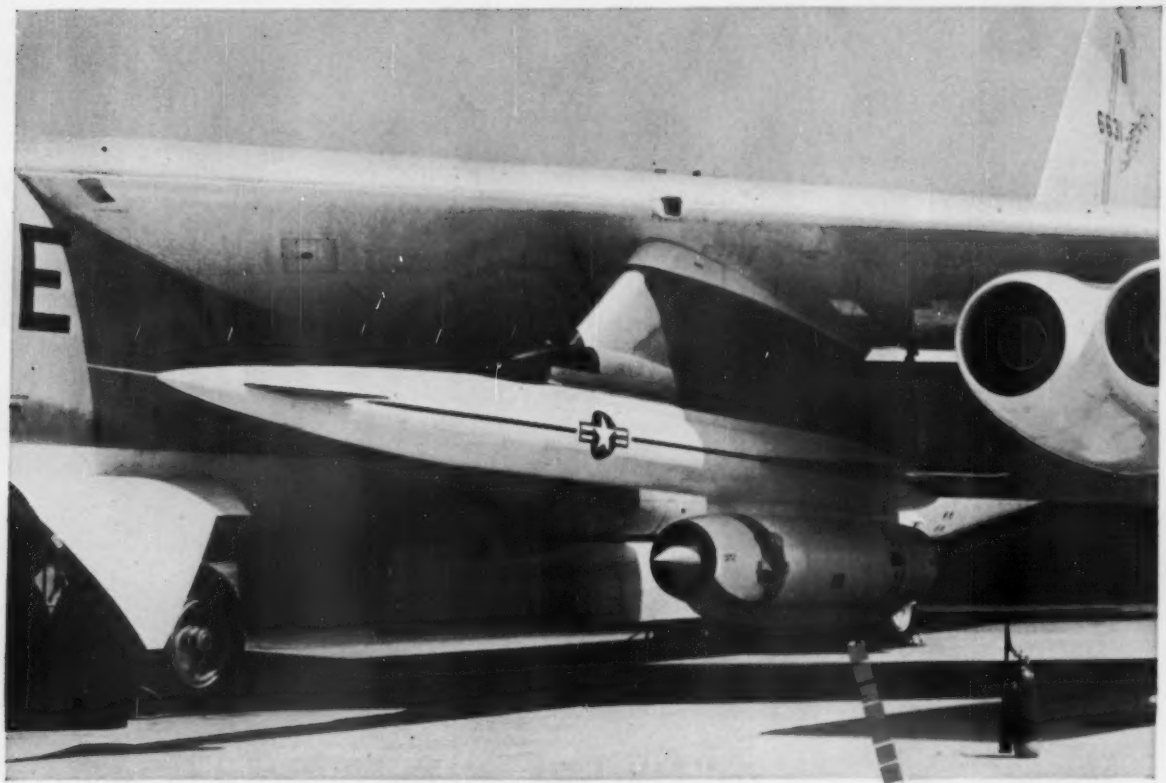

The quickest way to a "Hound Dog's" heart is through his stomach

The "Hound Dog" produced by North American Aviation's Missile Division for the Strategic Air Command, is capable of tracking down targets hundreds of miles from its launching point. When released from its Boeing B-52 mother ship, the Hound Dog's "Brain," an Autonetics-produced autonavigation system, makes it immune to enemy decoying or jamming. The "heart" of this missile is its powerful jet engine . . . and in keeping with defense requirements, servicing is swift — with Camloc Heavy-Duty Latches on the engine pod.

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WEST COAST OFFICE: 5410 Wilshire Blvd., Los Angeles 36, Calif.
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This Camloc Latch permits immediate access to J-52 engine which powers "Hound Dog" missile.

Circle Number 332 on Reader-Service Card

closes the circuit, cutting in the ignition system. A pilot warning signal may be incorporated. After successful restart, the switch opens cutting off ignition. Flamout detector is applicable to turbojet or turboprop engines.

AiResearch Mfg. Division, Garrett Corp., Phoenix, Ariz.

Aircraft Polishing Machine

Air-driven polishing machine is intended for military, airline and business aircraft.

The polishing machine, called the Whizmaster, dispenses polish as needed from a pressurized source. Compressed

air from 80 to 100 psi. is consumed at a rate from 12 to 14 cfm. The 7.5 lb. hand unit applies polish and polishes the aircraft with interchangeable brushes.

George Habiar:, 38 Blackburn Lane, Manhasset, N. Y.

Air Data Tester

Air data calibrator tester for military and airline jet aircraft supplies pitot and static pressures to instruments either on or off the aircraft. The equipment simulates altitudes to 80,000 ft. and air speeds to 650 kt.

The VPT 10 test unit utilizes electromechanical servos to regulate pressures and sensitive altitude and airspeed transducers similar to those used in autopilot holding controllers. A univer-

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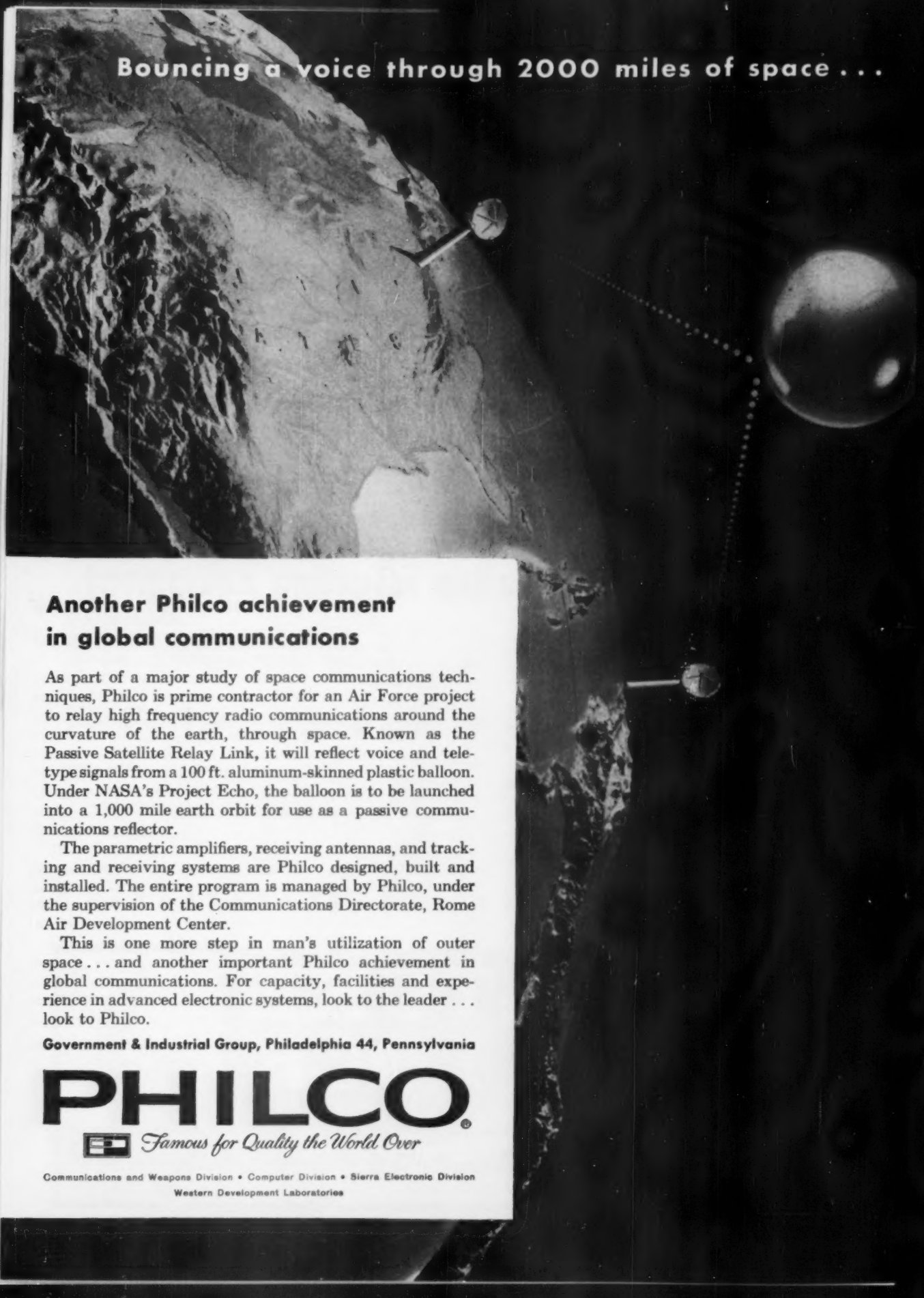

Another Philco achievement in global communications

As part of a major study of space communications techniques, Philco is prime contractor for an Air Force project to relay high frequency radio communications around the curvature of the earth, through space. Known as the Passive Satellite Relay Link, it will reflect voice and teletype signals from a 100 ft. aluminum-skinned plastic balloon. Under NASA's Project Echo, the balloon is to be launched into a 1,000 mile earth orbit for use as a passive communications reflector.

The parametric amplifiers, receiving antennas, and tracking and receiving systems are Philco designed, built and installed. The entire program is managed by Philco, under the supervision of the Communications Directorate, Rome Air Development Center.

This is one more step in man's utilization of outer space . . . and another important Philco achievement in global communications. For capacity, facilities and experience in advanced electronic systems, look to the leader . . . look to Philco.

Government & Industrial Group, Philadelphia 44, Pennsylvania

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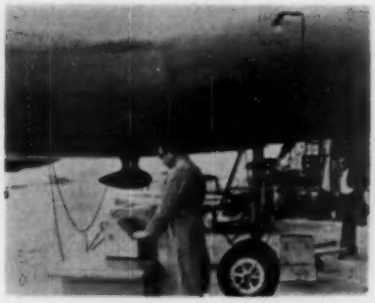
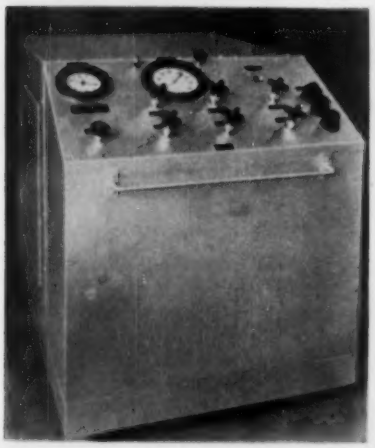


sal static port adapter fixes itself to the static port by means of a vacuum. Aircraft 400 cps. electrical power supplies the 38 lb. unit. Price, complete with accessories, is $4,928.

Intercontinental Dynamics Corp., 170 Coolidge Ave., Englewood, Calif.



Fuel System Tester

Transportable fuel system pressure tester is designed for the Pratt & Whitney JT3 and JT4 commercial jet engines.

Test cart control panel has a pressure gage, fuel temperature gage and a sight flow indicator along with motor start-stop buttons and control valves. Filtration to 10 microns is included in both supply and return lines. Pressure to 800 psi. may be generated. The test cart contains a 4½ gpm. piston pump, driven at 1,200 rpm by a 3 hp. motor. Dimensions of the 300 lb. card are 48 x 34 x 42 in. high.

REF Manufacturing Corp., 391 Jericho Turnpike, Mineola, N. Y.

High Temperature Bolt

High temperature bolting for aircraft and missiles is capable of 200,000 psi ultimate tensile strength at 900F temperature. The bolt has a 260,000 psi capability at standard temperatures. The EWB 926 bolt, made of heat treated chrome steel alloy, comes in #10 to ⅝ in. dia.

Standard Pressed Steel Co., Jenkintown, Pa.

AC

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monitor

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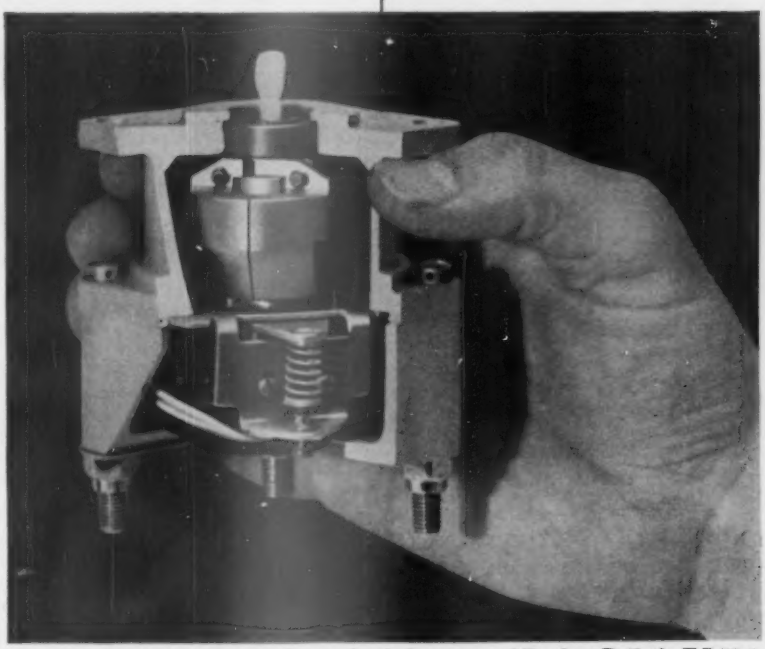
A proven production unit, the AC Speed Monitor has logged more hours of high-reliability service than any other speed switch in use.

Mechanically sensing rotating shaft speed, the Speed Monitor opens and closes two snap-action switches precisely, within 0.5% tolerance of calibrated settings.

This proven performance is designed into a one-pound package that's less than three inches in any dimension with a standard AN mounting pad allowing easy installation almost anywhere. Through-shaft design and second AN standard mounting pad permits installation of a tachometer or, for greater switching capacity, a second Speed Monitor.

The AC Speed Monitor is ruggedly built and permanently lubricated for thousands of hours of life, proved by severe laboratory environmental tests and over two years of customer field use.



For more details on this superb speed switch, a copy of Product Bulletin EC-58-1 may be obtained from the Sales Department, AC Spark Plug – the Electronics Division of General Motors, Box 622, Milwaukee 1, Wisconsin.

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Sikorsky S-62 demonstrates 2,000-pound payload delivery in the Himalayas at 14,000-foot altitude.

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WHAT'S NEW

Reports Available

The following reports were sponsored by the Office of Technical Services, United States Department of Commerce, Washington 25, D. C.

Properties of High-Temperature Ceramics and Cermets—Elasticity and Density at Room Temperature—S. M. Lang, National Bureau of Standards Monograph No. 6. Mar. 1, 1960. $.20; 45 pp. Order from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Development of a Fatigue Testing Apparatus for Testing Honeycomb Sandwich Structural Panels in Service-Simulated Sonic Fatigue—E. F. E. Zeijdel and W. H. Ashley, Midwest Research Institute, for Wright Air Development Center, U. S. Air Force. September, 1959. $1.00; 40 pp. (PB 161317)

Measuring Accuracy in Creep Tests—Part 2—A. Mellgren, Royal Institute of Technology, Stockholm, Sweden, for Wright Air Development Center, U. S. Air Force. October, 1959. $1.50; 60 pp. (PB 161356)

Studies in Human Isolation—S. J. Freedman and M. Greenblatt, Massachusetts Mental Health Center.—September, 1959. $1.50; 54 pp. (PB 161349)

Decision-Making Studies: Part 1—J. R. Hayes and E. C. Smith, U. S. Naval Research Laboratory. January, 1960. $.50; 9 pp. (PB 161052)

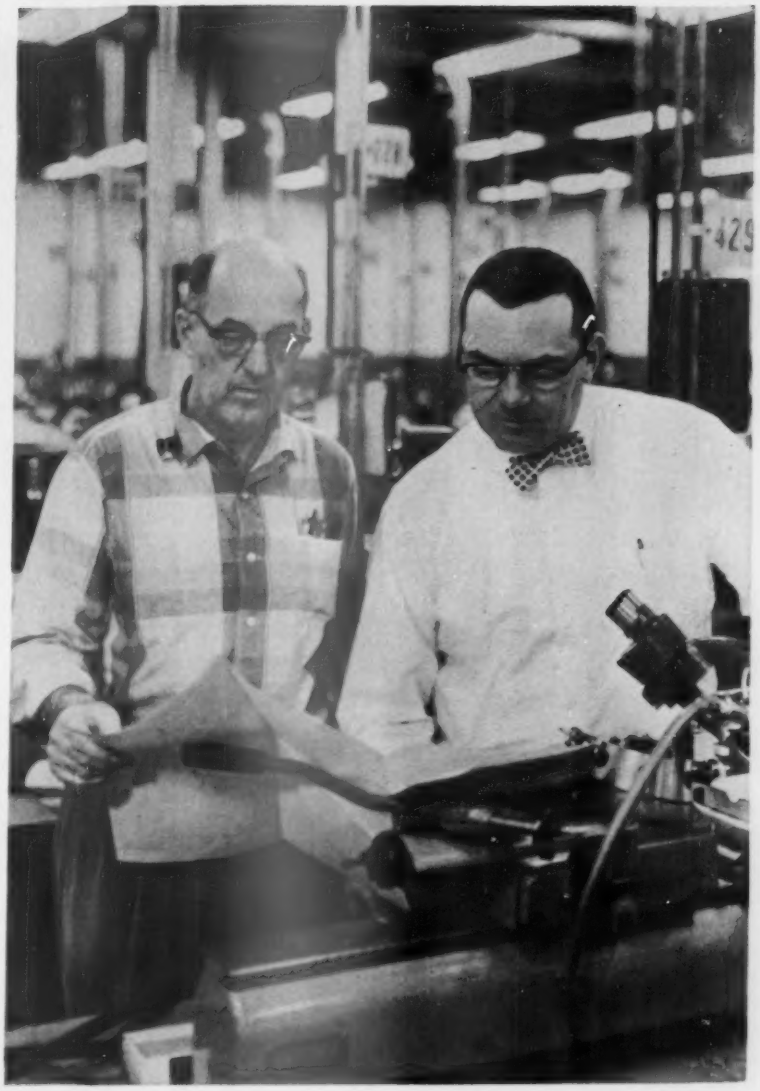
Ion Exchange and Other Chemical Methods for Beryllium Base Alloys—S. Kallmann, R. Liu, and H. Oberthin, Ledoux & Co. for Wright Air Development Center, U. S. Air Force. September, 1959. $1.25; 41 pp. (PB 161295)

Quarterly Progress Report on Toxicity of Beryllium—J. Cholak, L. H. Miller, and F. Princi, University of Cincinnati for Air Materiel Command. January, 1959. $.75; 30 pp. (PB 161319)

Rocket Propulsion Symbols—American Standards Assn., Inc., 10 E. 40th Street, New York 16, N. Y. $2.00.

Preparing for Patent-hood—Trak Electronics Co., division of CGS Laboratories, Inc., 49 Danbury Road, Wilton, Conn.

Radioisotopes in Science and Industry—Superintendent of Documents, Government Printing Office, Washington 25, D. C. $1.25.



These are men you should know

DELAVAN FUEL INJECTOR SPECIALISTS

Their names are Warren Ferguson and Robert Triplett. Ferguson is General Foreman of Delavan's Machining Division, Triplett is General Plant Superintendent. They have equipped Delavan with the men and machines to build fuel injectors to the most demanding tolerances. All designs are cleared with Bob Triplett before drawings are released for production. You can be sure Delavan can manufacture the fuel injector you need. These men and Delavan's staff of project and sales engineers are the main reasons leading turbo-jet, rocket and APU manufacturers rely on Delavan.

If fluid metering and atomization are part of your product, take advantage of Delavan's specialized experience and proven ability to deliver aircraft quality at high production rates. Send specifications to the address below for obligation-free recommendations.

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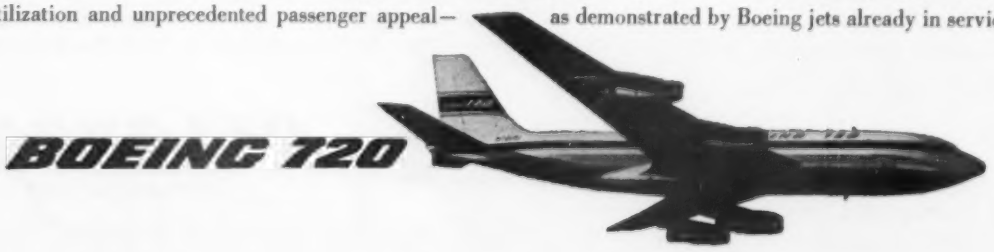
Newest jetliner in the sky—the Boeing 720! This superb new jetliner goes into service this summer over the routes of United and American airlines—and later with Braniff, Irish, Lufthansa and Western. An extremely fast and versatile airliner, the Boeing 720 cruises at more than 600 miles an hour, and is designed to operate profitably over short and medium range routes, and over stages up to 4,000 miles as well. The new 720 offers airlines the lowest seat-mile cost of any jetliner. In addition, it brings operators the advantages of extremely high initial utilization and unprecedented passenger appeal— as demonstrated by Boeing jets already in service.



DC-3 Modified for 'Crashworthiness'

By William S. Reed

Phoenix, Ariz.—Modifications to a cargo-executive Douglas DC-3, operated by Goodyear Aircraft Corp., have given it "crashworthy" characteristics affording maximum passenger safety in the event of an accident.

Key to the modification is a series of structural tiedowns linking occupant-to-seat, seat-to-floor and floor-to-fuselage to provide passengers with the greatest chance of coming through a survivable crash. Rather than increasing weight as might be expected, empty weight of the aircraft actually was decreased by 57 lb. by the modifications.

Safety Precepts

Engineering the modifications to the DC-3, Goodyear engineers followed precepts laid down by Aviation Crash Injury Research investigators at Cornell University. Main conclusion of ACIR researchers is that unnecessary injuries occur in aircraft accidents primarily because passengers tear loose from their tiedowns and are hurled into objects with lethal potentiality in other parts of the cabin, or the tiedowns hold but passengers are flung into nearby protrubances which cause injury or death. Another source of injury are objects which come loose from their moorings and are flung at the passenger with lethal force (AW Nov. 5, 1956, p. 61).

By designing passenger seats, safety belts and tiedown to withstand the same or greater force than the fuselage structure, the severe injuries and deaths normally caused by seats tearing free can be prevented.

In the modified DC-3, extra longitudinal stringers were built into the underfloor supports for anchoring each seat to the framing structure. For additional structural strength without weight increase, half-inch Bondolite flooring—an aluminum-faced, balsa-cored sandwich produced by Goodyear Aircraft—is bolted directly to the beams. Bondolite replaces plywood in the cabin and sheet metal in the cockpit. Although the longitudinal stringers add 200 lb. to the structure, use of the Bondolite floor—instead of plywood—saves more than the 200 lb. in weight.

Bolted directly to the reinforcing longerons are Aerotherm indexing tracks to which are attached the Aerotherm-manufactured passenger seats. Both seats and track will withstand 14.4g, more than the 12g ultimate load factor for which the cabin is stressed. Forces equivalent to 14.4g were applied to the seats during tests within a 20 deg. "yaw cone" of the direction of a head-on crash.

Goodyear's DC-3 has both forward and rearward facing seats. Forward seats feature low-pivoting breakover backs to minimize injuries caused by passengers striking the back of the seat ahead. Rearward facing seats have longer backs to prevent whiplash injury to the neck.

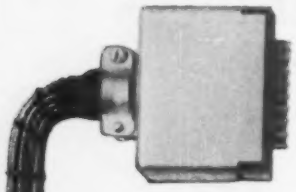
Seat backs are formed of ductile sheet metal, and each of the plane's 15 seats has an energy-absorbing device in the legs designed to begin yielding at a load of 9g.

Safety belts included in the modified aircraft are rated at a strength of 25g

ENERGY ABSORBING Aerotherm seats in Goodyear modified DC-3 can withstand up to 14.4g (above). Fixtures on fuselage wall no longer protrude and fire extinguisher, formerly located on rear bulkhead, now is located on the aft side to prevent it from being hurled about the cabin. Longitudinal stringers lie under each seat track (below) for stronger anchoring. Breakover feature is included in seats, which have longer back for avoidance of whip lash.

Thanks to you . . .

CTI SETS A NEW STANDARD FOR WIRING-HARNESS TESTERS



After carefully reviewing customer requests received during the past few years, CTI has designed an automatic tester incorporating every feature desired by the manufacturer or user of wiring harnesses and cables. Compact, inexpensive, and simple to operate, the new Model 165 Cable Tester can handle the most complex wiring test problems. Test capacity can be increased indefinitely by adding small switch-unit modules to the basic equipment.

Only the CTI Cable Tester offers all these features:

- Completely automatic
- Simple operation, go/no-go readout
- Simultaneous continuity, leakage, and hi-pot measurements on each test
- Leakage measured from the circuit under test to all others
- Self-testing and fail-safe — validity of tests is assured
- Wide choice of test parameters from calibrated, front-panel controls
- Simple programming without complex patchboards
- Branch circuits can be programmed without sacrificing additional test points
- Precision bridges assure accuracy and stability of measurements
- Provides control of relays in the circuit under test
- Accessory printer lists rejects
- Manufactured by a company that has pioneered automatic testing

SPECIFICATIONS

Continuity test currents: Off, 0.1, 0.5, 1.0, and 2.0 amps d-c

Continuity accept limits: 0.1, 0.5, 1.0, 5.0, and 10.0 ohms (maximum test current on the 1-, 5-, and 10-ohm ranges is 1.0 amp.)

Hi-pot voltages: Off, 28, 100, 500, 1000, and 1500 volts d-c (hi-pot current limited to approximately 1 ma)

Leakage-resistance limits: 1, 5, 10, 100, and 500 megohms

Hi-pot dwell time: continuously variable from 0.2 secs to 100 secs

Test rate (maximum): 5 circuits per second (0.2 seconds dwell time)

Test capacity: 200 tests plus 200 for each complete, additional Switching Unit used. Switching Unit panel may be supplied with 50-test switch modules as needed.

Each of the above test parameters can be selected independently of the others. All values are set with front-panel selector switches.

Engineers: Career opportunities are currently available at CTI

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SHOULDER HARNESS has inertia reel. Arrows indicate heavy padding for crew protection.

and have metal-to-metal locking devices for easy opening and positive fastening.

Coffee urns, fire extinguishers, crash axes and other heavy objects that could inflict lethal blows by tearing free in the event of a crash have been fastened securely and, when possible, have been placed on the aft side of bulkheads. Fastening devices for such fixtures are stressed to at least 14.4g.

A baggage cabinet in the rear of the aircraft also is stressed for 14.4g for its maximum load to prevent pieces of luggage from being thrown against occupants.

Heavy padding also is provided for fuselage walls and ceiling in the vicinity of cockpit and galley.

More passenger protection is gained by recessing cabin lights and ventilation outlets and by clearly marking the emergency exits. Instructions are plainly marked on the inside of the normal entrance so that this can be opened by any of the passengers if crew members are incapacitated.

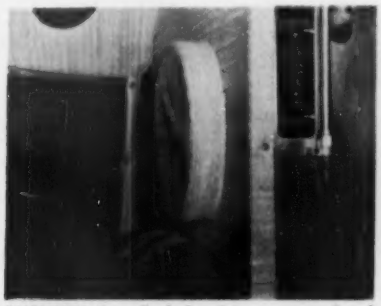
Access points on the exterior of the aircraft also are clearly marked so that individuals unfamiliar with aircraft can gain entrance to effect rescue. A minimum of words is used to describe procedures for gaining entrance and procedures are simplified to the minimum number of movements.

Cockpit Padding

Protection for the pilots results from removal of sharp corners and protruding objects in the cockpit area or padding these where they cannot be removed or relocated. Pliotrim—a Goodyear heavy padding—covers hydraulic lines and windshield wiper actuators on the instrument panel, the magnetic compass housing, window frames and assorted bolt and screw heads. Inertia reel-lock shoulder harnesses are provided for both pilots.

Goodyear estimates that now, with the basic engineering already done, it would cost about $25,000 and take about 600 man hours to convert another DC-3 to the same "crashworthiness" built into its aircraft.

The research evaluation for Goodyear was done by A. Howard Hasbrook, formerly director of Cornell's Aviation Crash Injury Research, now a crash-safety consultant, located in Gilbert, Ariz.



CUSHION for pilot's head is an example of special padding in cockpit.

TWO-STEP directions are provided rescuers for opening cabin door from outside.

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For toughness and flexibility over the wide range of —90°C to 250°C, as well as chemical inertness, nonflammability, abrasion resistance, zero moisture absorption—and of course superior electricals—you know to choose TEFLON* tubing. And for precision manufacturing and inspection, Teflon and other tubings bearing the FLEXITE label conform to Markel's high standards of excellence. Ask for samples.

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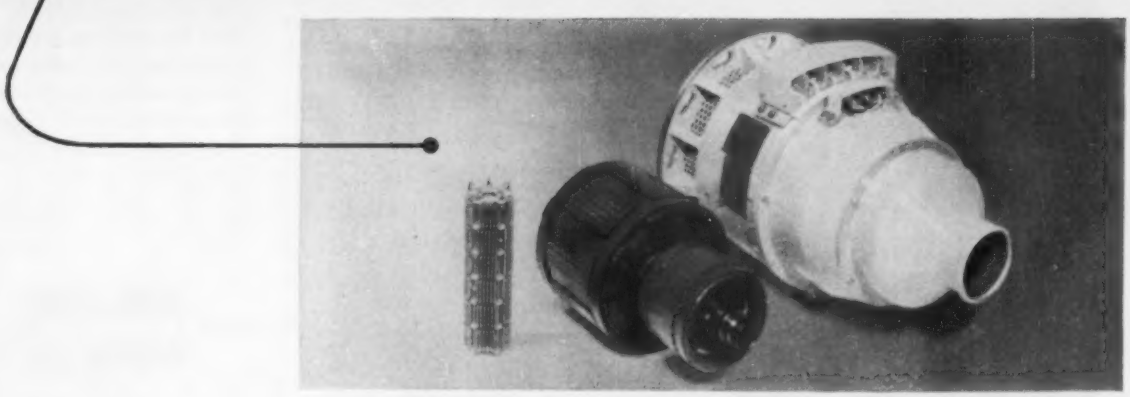

GREAT RELIABILITY and longer service life result from elimination of sliding or moving contacts in Westinghouse brushless generating systems. A single rectifier bundle (left above) mounted within the rotor assembly (center) eliminates commutators, carbon brushes, and collector rings. High temperature silicon diodes, produced by Westinghouse research in semiconductors. make this possible.

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Wherever they fly

Westinghouse Brushless Generators set amazing reliability records

Wherever they fly—in giant 707 commercial jet airliners, in supersonic jet bombers or sleek, lightweight jet trainers—Westinghouse brushless generators and complete electrical systems are setting unmatched records of dependability.

For example: In one airline's fleet of 707s, Westinghouse 30 KVA brushless AC generators, at the end of 1959, had accumulated 2970 hours mean time between removal. This is 3 to 5 times better than the service given by ordinary brush type generators.

On the same fleet of 707 aircraft, Westinghouse voltage regulators, designed with static components, have attained a reliability factor of 12,780 hours; control panels, with static circuitry, 6085 hours.

Behind this remarkable, trouble-free generator performance is the advanced Westinghouse *brushless* design, which features a rectifier assembly of high-temperature silicon diodes instead of the usual brushes, commutator and slip rings.

Write for complete information on these brushless generators and equipment, and advanced new constant frequency devices now in development. A. L. Paquette, Marketing Manager, Aircraft Equipment Department, P. O. Box 989, Westinghouse Electric Corporation, Lima, Ohio.

WESTINGHOUSE
DEFENSE PRODUCTS GROUP

PROVED IN SERVICE—Westinghouse brushless AC generators are produced for commercial jet airliners, and military aircraft such as the coming Boeing B-52H, Convair B-58, North American A3J-1, and Northrop T-38. Sizes range from 8 KVA to 120 KVA—the world's largest aircraft generator—and both air cooled and oil cooled types are built. Many thousands of hours of trouble-free flight prove dependability of Westinghouse electrical systems.

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SMALL SIZE ONE CUBIC INCH MAX.

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Actual Size
1" dia. x 1" long

High vibration performance: ±35G to 5,000 cps
Pressure ranges Absolute, differential and gage pressures: 0-3 to 0-400 psi
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Standard Nominal Potentiometer Resistances: 400 to 10,000 ohms
Electrical Connection: Pigmy receptacle or soldering terminals
Mounting: Flange or bulkhead

Write for complete information.

COLVIN LABORATORIES, INC.
364 Glenwood Avenue, East Orange, N. J.

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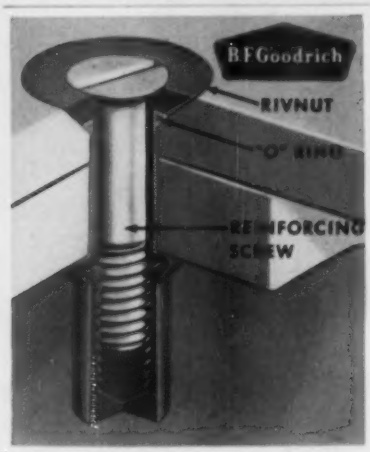

RIVNUTS® provide fuel-tight fastening

This Seal-Head RIVNUT, with rubber "O"-Ring and high tensile reinforcing screw, is approved for fastening primary aircraft structures. Makes a fuel-tight seal; "O"-Ring withstands temperatures from -65° to 225°. RIVNUTS are the only one-piece blind rivets with internal threads; installed quickly by one man with a heading tool.

B.F.Goodrich
Rivnuts
Dept. AW-6C, Akron, Ohio

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CAB Accident Investigation Report:

Maintenance Procedures Cited In 707 Landing Gear Accident

At 0029 EST, on July 12, 1959, Pan American World Airways Flight 102 made a successful emergency landing at New York International Airport after losing two of the four wheels of the left main gear. The airplane, a Boeing 707, N 707PA, received major damage to the left main landing gear. Four of the 102 passengers aboard were injured during deplaning.

The loss of the two wheels was caused by a failure of the forward truck beam. This failure was induced by undetected damage to the beam when it contacted the lower torsion link assembly antirotation bolt. This could only have occurred on one of two previous flights. On one of the previous flights the snubber failed on takeoff and on the other flight the snubber had been removed. Either condition would have permitted the truck beam to pitch up sufficiently to cause this contact. The manufacturer has prepared several engineering changes which will prevent recurrence of this type of failure. These changes are discussed in the report.

During the emergency, which lasted approximately four hours, radio and television announcements attracted to the airport large crowds of curiosity seekers who seriously hampered the work of emergency rescue personnel.

Representatives of the Port of New York Authority, New York Fire Department, and the Police Department are reviewing emergency procedures on a continuing basis to improve them whenever possible.

INVESTIGATION

Pan American World Airways (PAA) Flight 102 is a regular nonstop flight from New York International Airport (Idlewild) to London, England. The trip of July 11 carried 102 passengers and a crew of 11.

Routine preparations for the flight were completed. Takeoff was planned on runway 25L with a gross weight of 244,805 lb., of which 94,547 lb. consisted of fuel.

The flight, which had been delayed approximately 30 min. for a wheel change, took off at 2037[1]. Immediately after the aircraft became airborne, one of the Idlewild tower controllers saw what he believed to be wheels separate from the undercarriage and fall into the bay at the end of the runway. He immediately notified the flight and called the office of the Port of New York Authority to have personnel investigate and report the identity of the object. About one hour was required for crews to retrieve the part from shallow water about 50 ft. from the shore. The object was then identified as two wheels from the aircraft with a portion of the truck beam attached.

The crew stated that its takeoff was completely normal and that when the 707 was airborne the landing gear handle was raised to the "up" position. The three green indicator lights went out and the red, "gear in transit," light came on. This light remained on indicating that the gear did not retract properly. It was about this time that the tower notified the flight concerning the object which had fallen from the aircraft.

The flight remained in the local area circling at low altitude to determine what damage had been sustained. A visual inspection by the crew revealed that the left gear was extended but not locked down, and that the two forward wheels of the four-wheeled truck were missing, along with a major portion of the forward truck beam.

After a careful appraisal of the situation the captain decided to land at Idlewild with the landing gear extended. He requested that the last 3,000 ft. of runway 13R be foamed as a precautionary measure. It was estimated that the foaming operation would require about two hours. The aircraft had enough fuel remaining to circle for about three hours more at low altitude. Remaining aloft until the foaming operation was complete would also enable the captain to reduce the fire hazard and to lighten the aircraft to the desirable landing weight through fuel burnoff rather than by dumping.

While preparations on the ground were being accomplished, the flight made ready for the landing. The landing gear was lowered manually and locked down. Passengers were instructed in the proper emergency procedures and aircraft evacuation methods. Crew members were assigned to each exit to actuate the emergency slide chutes. Everything was in readiness prior to the landing attempt.

On the ground, preparations were carried out under the direction of Port Authority officials. About 2136 an emergency alarm was actuated and equipment and personnel from the New York City Fire and Police Departments responded in accordance with established agreements with the Port Authority. These mutual agreements set out procedures and responsibilities for each of the three organizations to follow in coping with emergencies at the airport.

Radio and television broadcasts of the emergency attracted thousands of sightseers to the airport. All access roads were blocked by the traffic congestion. The police established barricades to access points to the airport allowing only emergency equipment and authorized personnel admittance.

A considerable number of unauthorized persons gained entrance to the runway area and hampered the work of the Port Authority and Fire Department personnel.

The foaming operation was completed about 2325 and the emergency vehicles were recharged with foam and water. By 0010 the emergency equipment was made ready and positioned for the landing. A final check was made to make certain that

[1]All times herein are Eastern Standard based on the 24-hr. clock.

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the runway was clear of personnel. After ensuring that all unauthorized persons were north of taxiway Q, which is 850 ft. north of runway 13R, the control tower was notified that preparations were complete.

The captain, after receiving landing clearance from the tower, made his final preparations for the landing. Based on the gross weight of the aircraft, which was estimated to be 155,000 to 158,000 lb., reference speed was calculated to be 130 kt. and the approach was made.

Flaps were fully extended and touchdown was made within the first 1,000 ft. of the runway with the right main gear. Spoilers were raised immediately and as the left main gear and nose wheels made contact full reverse thrust was applied. It was possible to hold the aircraft straight using differential reverse thrust until the full weight settled on the left gear and the left strut began to drag on the runway. Right brake was sufficient to maintain directional control and at 0029 the aircraft came to a stop on the runway about 1,200 ft. short of the foamed area.

Although the strut and scraping on the runway generated heavy sparking throughout the landing roll, no fire occurred. Immediately after the aircraft stopped, the exit doors were opened and emergency slide chutes were released.

The Port Authority emergency vehicles surrounded the aircraft to assist in evacuating the passengers. Several people left the aircraft via the chutes; however, within a short period of time the chutes were cut away and the remaining passengers were evacuated via emergency stairs placed in position by Port Authority personnel. All 102 passengers were out of the aircraft in approximately three minutes. It was estimately 400 to 600 people surrounded the aircraft after it stopped. Most of these persons were the curious whose presence seriously hampered the efforts of the rescue workers. As there was danger of tires blowing out or the collapse of the damaged landing gear, the sightseers were repeatedly asked to "move out of the danger area." These warnings were ignored and finally a Port Authority fire truck sprayed the crowd and cleared the area.

Examination of the forward section of the hollow steel truck beam for the left landing gear revealed the presence of a flat peen mark on its top face 7½ in. forward of the truck fulcrum. A crack extending longitudinally approximately 1½ in. each way from the peen mark was evident. Although the clamshells and polishing normally associated with metal fatigue were not present, there were the well-defined end lines of a fatigue-like crack which started at the inside surface of the truck beam. The end lines and the lack of ductility indicate the probability of more than one cycle of loading. Beyond these end lines the longitudinal crack was extended in instantaneous fractures 3½ in. forward and 1⅛ in. behind.

A second less well-defined peen mark was found about one-half inch forward of the above-described peen mark. Although this second mark appeared to have been made by a sharper edge, no evidence of fatigue was present. A peripheral helical fracture originated at this peen mark and ran completely around the truck beam to the left, terminating at the longitudinal crack. This peripheral fracture ended 1½ in. forward of its point of origin.

At the forward end of the longitudinal crack, another instantaneous fracture ran helically to the right completely around the beam and beyond to a point on the bottom of the beam three inches to the rear of the front axle centerline. A third instantaneous fracture occurred at the rear of the longitudinal crack and ran peripherally to the left. The terminus of this fracture was ground off by the sliding action on the runway.

The left main gear lower torsion link assembly antirotation bolt was still in place but its nut was missing. Some threads were damaged and the end was slightly bent. The bolt end surface had two peened areas, each the same size and shape as the peen mark on the truck beam. The lower spacer was also peened on the edge of its lower surface.

Metal Analyzed

In a metallographic examination conducted by the National Bureau of Standards numerous cracks were found, some of which appeared to be intergranular. Indications of intergranular cracking were also found on the main fracture, suggesting the possibility that hydrogen embrittlement contributed to the cause of the failure.

The microstructure was typical of quenched and tempered steel but in some areas the nonmetallic inclusions were more numerous than is considered normal for aircraft quality steel.

Hardness testing of the steel near the fracture produced a Rockwell number of

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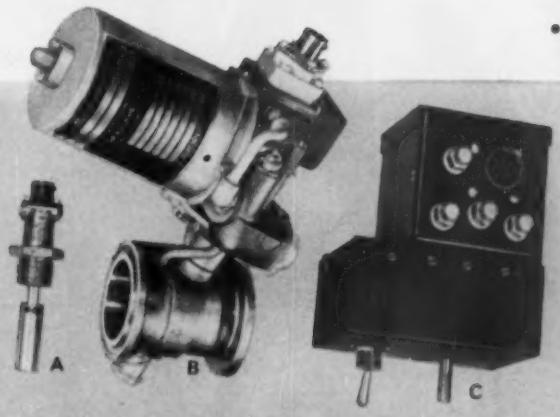

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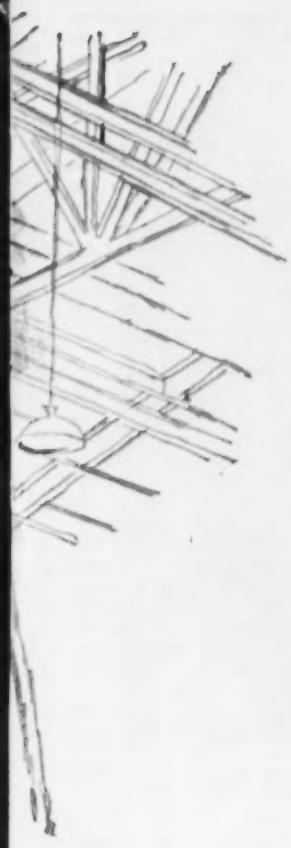

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53C, showing that the beam had been heat-treated to the specified tensile strength range of 260,000 to 280,000 psi.

... The truck beam is considerably harder than the antirotation bolt and any contact between the two which would deform the truck beam would also damage the softer bolt.

During takeoff and landing the landing gear truck may be subjected to extreme and violent vertical oscillation over runway pavement at high speeds. In addition, it has been determined that unequal braking during the retraction cycle may also cause similar violent oscillations. Therefore, the landing gear truck is fitted with a "hydraulic shock absorber" snubber assembly. Its purpose is to damp these oscillations of the truck beam around its single pivot point at the lower end of the oleo strut. It also serves to limit displacement at the truck beam to a maximum of 10 deg. above the 15 deg. below the horizontal. Without this limiting action by the snubber the truck beam is free to pivot to an angle at which it will contact the antirotation bolt in the lower torsion link assembly. Investigation disclosed that the position of the peen marks on the truck beam of N 707PA corresponded precisely with the point at which the beam would contact the antirotation bolt during over travel of the truck beam.

A review of the history of the landing gear on this aircraft revealed that a snubber failure had occurred on takeoff from Boston on July 7, 1959. After landing in New York, the snubber was replaced. The antirotation bolt was damaged but the nut which was missing was replaced. On July 9, 1959, at Paris, it was noted that the snubber terminal attach bolts were sheared. They were replaced with temporary bolts and the aircraft proceeded to Santa Maria. On landing, inspection showed that the temporary bolts had sheared. At this time the snubber was removed and the aircraft was flown to Idlewild where the same snubber was reinstalled. Testimony of Pan American representatives at the public hearing indicated that no damage occurred to the antirotation bolt on either the Boston takeoff or the Santa Maria takeoff. They also stated that the damage inflicted on the bolt in this accident was the result of the contact between the truck beam and the bolt after the beam had failed. One additional round trip between New York and London was made, without incident, before trip 102.

ANALYSIS

The Board believes that the landing gear truck beam on N 707PA was damaged on a previous flight by contact with the lower torsion link assembly antirotation bolt.

The design of the landing gear is such that this damage can occur only if the snubber is removed or is broken from one of its end fittings. The beam could have been peened during the flight from Boston, July 7, after the snubber failed, or on its flight from Santa Maria, July 9, when the snubber had been removed. Also, since the examination of the fracture indicates multiple loading, the damage may have been done during both of the flights.

Because the beam and the end of the antirotation bolt are angled 15 deg. from each other at the point of their contact, the end of the bolt must be deformed to that angle to leave a flat mark on the beam surface. If, as PAA claimed, the bolt installed at the time of the accident was damaged during the accident, another bolt would have had to have been installed previously. This bolt would have had to have been flattened as mentioned before in order to peen the truck beam in the manner it did. This previously damaged bolt, if there was one, was either replaced without appropriate notation in the records or was the bolt in place at the time of this accident. Either action indicates improper maintenance practice.

The longitudinal fatigue-like crack originated at this flat peen mark. As the snubber was properly installed at takeoff, no contact between the beam and the bolt was possible until the forward truck beam had separated from the aircraft as a result of forces to which the weakened beam was subjected on takeoff.

Although a considerable number of unauthorized persons were on the landing area during the emergency, none was closer to the runway than taxiway Q, which is 850 ft. north, during the actual landing. The Board takes cognizance of the fact that the normal Saturday night visitor population of Idlewild is upwards of 10,000 people. In addition, there are over 200 doors by which these persons could gain entrance to the aircraft operating areas.

It is to be noted here that there was no interference by spectators during the actual landing of the aircraft. The runway was cleared of all personnel during this time and it was not until the aircraft had come to rest that the numerous persons crowding

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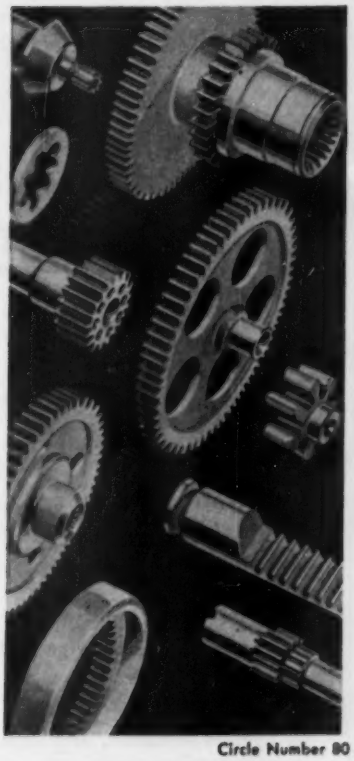

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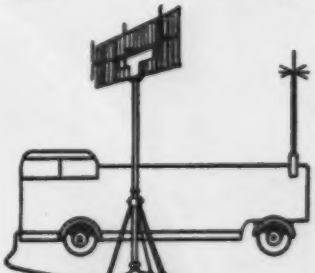

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around became a serious problem. Ground preparations were well executed.

The investigation indicates that the failure of the truck beam was due to a crack produced by impact loads on its top surface. The initial crack was propagated to complete fracture by additional impact and normal service loads. Some hydrogen embrittlement and an unusually large number of non-metallic inclusions in the area where the fracture started may have contributed by decreasing the ductility of the steel.

As a result of a study of snubber failures, the manufacturer has prepared several changes which it is anticipated will eliminate further difficulty. The size of the orifices in the hydraulic piston of the snubber assembly are to be reduced to increase its load rate, and the pressure relief setting is to be increased from 8,000 psi. to 12,500 psi. These modifications will increase the effectiveness of the damping action of the snubber assembly. The automatic wheel braking valve setting is to be reduced from 450 psi. to approximately 175 psi. This should decrease the tendency of unequal braking causing the oscillation of the truck beam. In addition, the pressure in the leveling cylinder assembly is to be increased from 925 psi. to 1,500 psi.

These changes should prevent excessive oscillation of the truck beam caused by either unequal braking during retraction or by displacement of the truck during taxi or takeoff roll.

The Board concludes that the agreements between the Port Authority and New York Fire and Police Departments, which have been in existence for a number of years, are sound. Many emergencies have been covered in the past following the practices established in these agreements. While improvements, alterations, and modernization of the procedures are indicated from time to time, it is believed the policy of mutual assistance can and will continue to operate successfully. Subsequent to this accident, representatives of the National Association of Broadcasters have advised that when radio and television coverage of emergency news is being broadcast, a specific request will be made to listeners "to refrain from doing anything that would hamper the efforts of the authorities whose responsibility it is to cope with the emergency."

The Board realizes that an aircraft emergency is news and that news reporting media constantly monitor aircraft radio frequencies. It is not to be inferred that this practice is in any way improper. It is a fact, however, that the public broadcasts in this case attracted large crowds of persons to the scene. The resulting traffic completely choked the access highways to the airport boundaries. This could give rise to a serious problem affecting air safety and one which will be given further study by the Board.

PROBABLE CAUSE

The Board determines that the probable cause of this accident was the failure of the forward truck beam of the left landing gear.

By the Civil Aeronautics Board:

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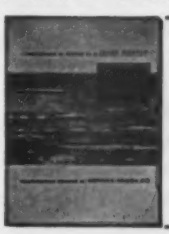

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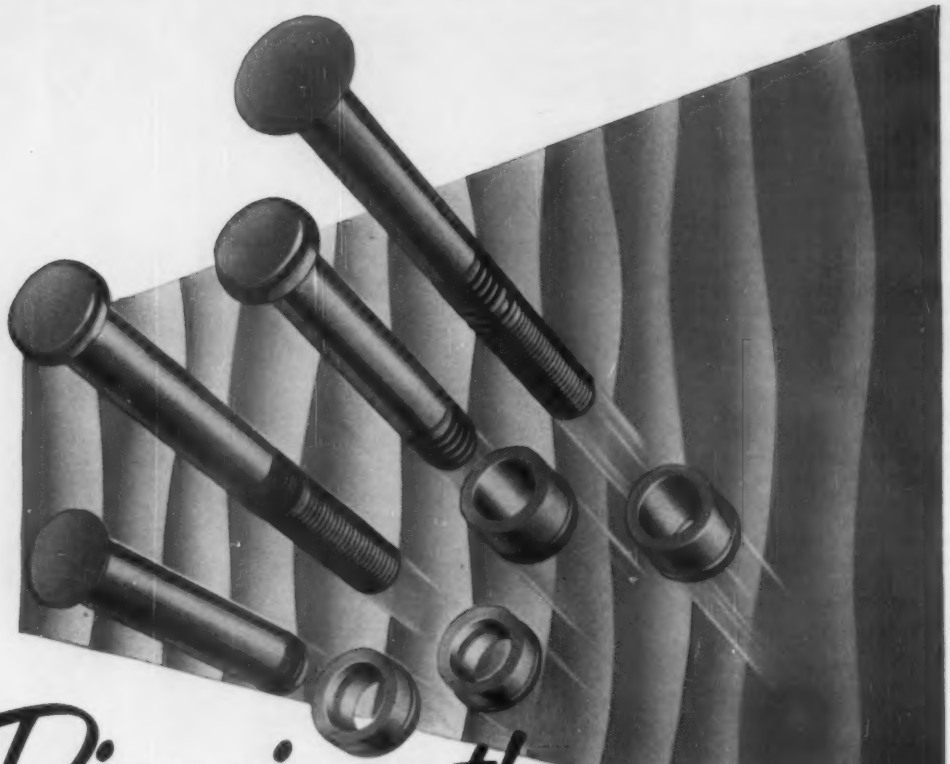

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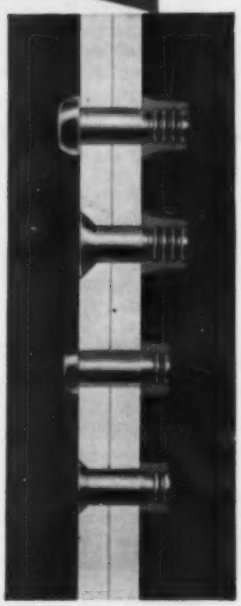

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of this accident at 2045 EST, July 11, 1959. Investigators were on the scene during the emergency and immediately initiated an investigation in accordance with the provisions of Title VII of the Federal Aviation Act of 1958. A public hearing was held in New York City on July 30 and 31, 1959.

AIR CARRIER

Pan American World Airways, Inc., is a New York corporation with its main offices in New York, N. Y. The corporation operates as an air carrier under a certificate of public convenience and necessity issued by the Civil Aeronautics Board and an air carrier operating certificate issued by the Federal Aviation Agency (formerly Civil Aeronautics Administration). These certificates authorize the carrier to engage in air transportation between various points in the United States and foreign countries, including the route involved in this instance.

FLIGHT PERSONNEL

Capt. Edward F. Sommers, age 44, was employed by Pan American World Airways on Nov. 29, 1939. He holds a valid FAA airline transport pilot certificate with a rating for the Boeing 707. He had a total of 17,100 flying hours, of which 170 were in the Boeing 707. He completed his latest emergency class and ground refresher course May 11, 1959. His latest FAA (formerly CAA) physical examination was passed Apr. 8, 1959.

Flight Officer William H. Riester, age 42, was employed by Pan American World Airways on Mar. 16, 1942. He holds a valid FAA airline transport pilot certificate with a rating in the Boeing 707. He had a total of 11,270 flying hours, of which 144 were in the Boeing 707. He completed his latest ground refresher course May 20, 1959, and his last emergency class Apr. 14, 1959. His last FAA physical examination was passed Mar. 21, 1959.

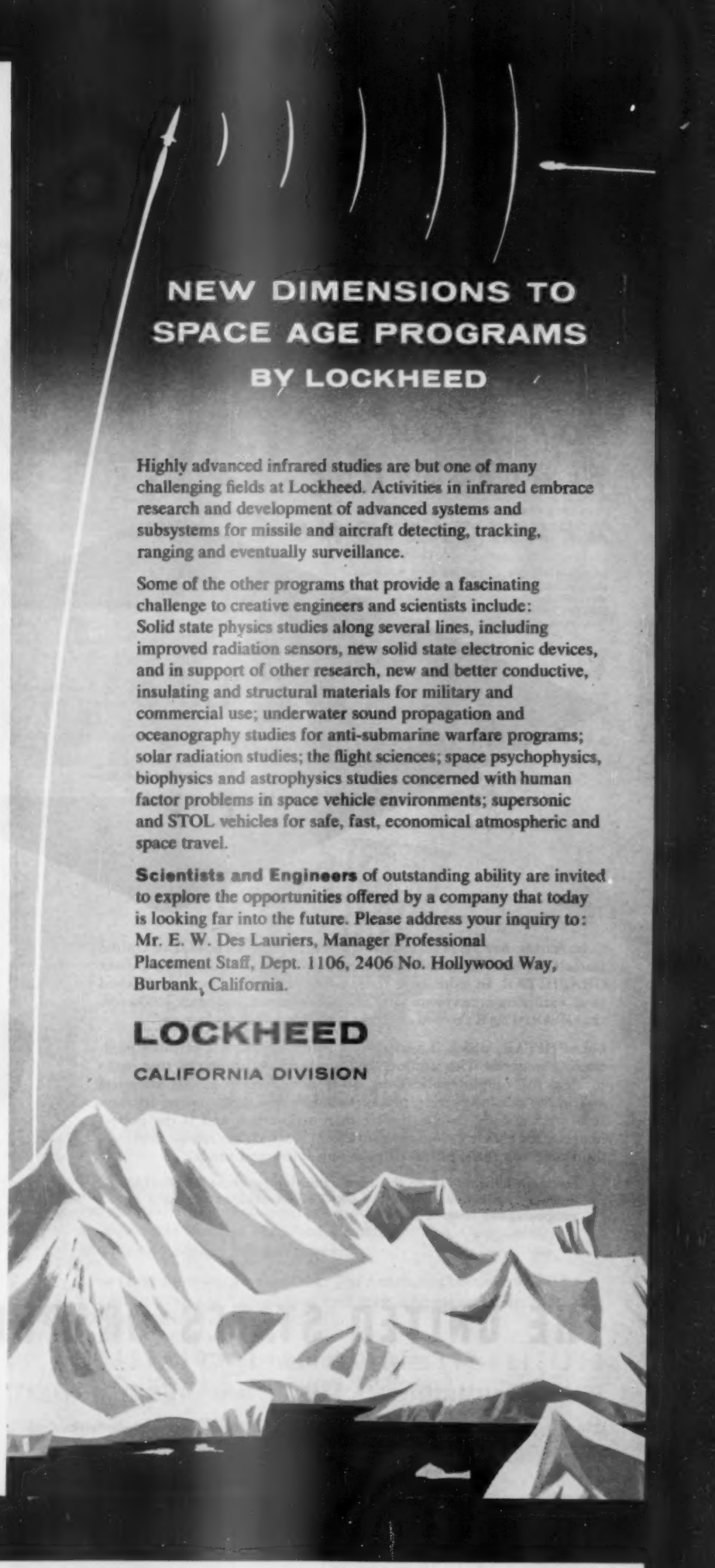
Navigator Walter E. Hoffman, age 37, was employed by Pan American World Airways on Dec. 26, 1951. He holds a valid FAA commercial pilot certificate and navigation certificate. He had a total of 3,424 flying hours, of which 249 were in the Boeing 707. His last physical examination was passed Oct. 4, 1958. His latest emergency class and periodic refresher courses were taken Apr. 5, 1959.

Flight Engineer August G. McKinney, age 47, was employed by Pan American World Airways May 11, 1936. He holds a valid flight engineer certificate with airplane and engine ratings. He had a total of 14,090 flying hours, of which 733 were in the Boeing 707. His latest FAA physical examination was passed Dec. 1, 1958. He completed his latest emergency class July 21, 1958.

The flight service crew, consisting of Pursers Edmund Trudelle and Mario De Minices; Stewardesses Muriel Orvidson, Mona Nordby and Ursula Kempin; and Steward John Treadwell, were are properly qualified in the Boeing 707.

THE AIRCRAFT

N 707PA, a Boeing 707, serial number 17587, was owned and operated by Pan American World Airways, Inc. The aircraft was equipped with Pratt & Whitney JT3C turbojet engines.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WHO'S WHERE

(Continued from page 71)

Changes

Forrest Warren, chief engineer, Aerolab Development Co., Pasadena, Calif., subsidiary of Ryan Aeronautical Co. Also: **William Fischer,** financial manager; **Frank Bolles,** administrative engineer.

Lloyd Percell, sales manager-air transport sales, Lear, Inc., Santa Monica, Calif.

James G. Wenzel, coordinator of anti-submarine warfare programs, General Dynamics Corp., Washington, D.C.

James M. Beggs, manager of the newly-established Typhon (Navy's fleet anti-air warfare system) Weapon System Control Department, Westinghouse Electric Corp., Baltimore, Md.

Robert J. Lodge, manager of engineering test, North American Aviation's Rocketdyne Division, Canoga Park, Calif.

William R. Wilson, executive assistant to the executive vice president, California Division of Lockheed Aircraft Corp., Burbank, Calif.

Steve E. Strem, manager, Technical Services Department of Telecomputing Corp., Los Angeles, Calif.

Jules Kravetz, director of government relations, Aerolab Development Co., Pasadena, Calif., subsidiary of Ryan Aeronautical Co.

Robert D. Lavin, manager, Systems Engineering Department of Gulton Industries' Ortholog Division, Metuchen, N. J.

George R. Chambers, III, manager-research and development marketing, Eitel-McCullough, Inc., San Carlos, Calif.

Dr. Hanns S. Wolff, chief, Electronics Laboratory, Republic Aviation Corp., Farmingdale, N. Y.

Capt. James A. Maxwell, operations manager for Pan American World Airways' Latin American Division.

Sherwin U. Miller, M. D., director, Life Sciences Division of Space Systems Laboratories, Space Systems & Industrial Automation, Inc., Burbank, Calif.

Dr. Albert M. Soldate has joined the technical staff of National Engineering Science Co., Pasadena, Calif.

Pierre F. G. Mulot and **George L. Hern,** assistant managers of public relations, New York divisional headquarters of Air France.

John J. Jarosh, manager of inertial devices, and **Dr. William L. Parker,** manager of guidance systems, engineering department research and development laboratories, Hughes Aircraft Co., Culver City, Calif.

Harry E. Lockery, manager of engineering, Electronics & Instrumentation Division, Baldwin-Lima-Hamilton Corp., Waltham, Mass.

Frank G. Denison, manager, and **Maj. Gen. John S. Mills** (USAF, ret.), assistant manager of the newly formed Lunar Systems Activity, Ford Motor Co.'s Aeronutronic Division, Newport Beach, Calif. Lunar Systems Activity is composed of the following components: System Integration, headed by **Robert F. Nease;** Applied Mechanics, under **Wilbur W. Hawley;** Electronics, directed by **Robert E. Heckert;** Product Qualification, headed by **John E. Richards.**

Arthur Donald Watt, head of the Boulder (Colo.) Research and Development Laboratory Division of Developmental Engineering Corp.

Dr. Wolfgang W. Gaertner, manager-electronic semiconductor research and development, CBS Laboratories, Stamford.

Richard A. Schram, marketing manager-flight systems, Chicago Aerial Industries, Inc., Melrose Park, Ill. **Richard G. Farrell** succeeds Mr. Schram as director of public relations. Also: **John E. Smircina,** controller.

Maj. Gen. Eugene P. Mussett (USAF, ret.), site integration manager for the Martin Co. at the Titan ICBM base at Ellsworth AFB, Rapid City, S. D., and **Warren F. Opitz,** manager of field installations.

Air Vice Marshal Sir Laurence Sinclair, controller of ground services, British Ministry of Aviation.

Gerald C. Johnson, Jr., manager of the B-58 Hustler program at the Buffalo (N. Y.) Operations of Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc.

R. E. Horner, manager-marketing, General Electric Co.'s Light Military Electronics Department, Utica, N. Y.

Arthur W. Dobson, manager of marketing research, Perkin-Elmer Corp., Norwalk, Conn.

Allen S. Ginsburgh, manager-Materials and Fabrication Division, Solid Rocket Plant of Aerojet-General Corp., Sacramento.

Dr. D. M. Allison, technical assistant to the vice president-engineering and research, the Bendix Corp., Detroit, Mich.

Loren Preston, service engineering representative-Washington, D. C., Apparatus Division of Texas Instruments, Inc.

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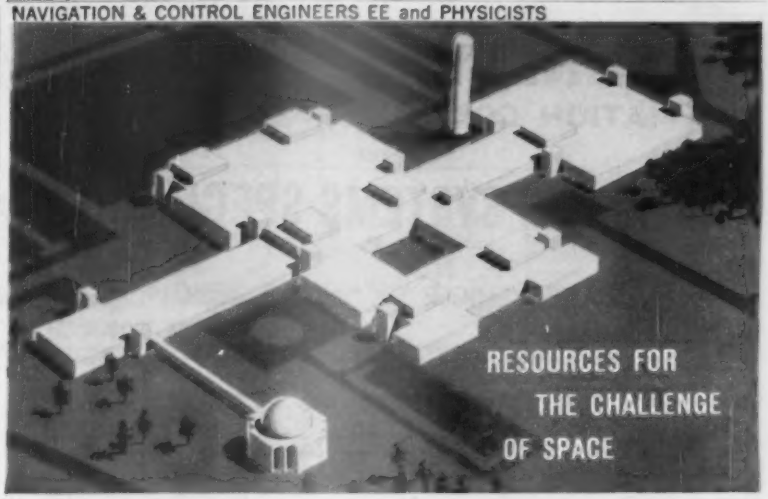

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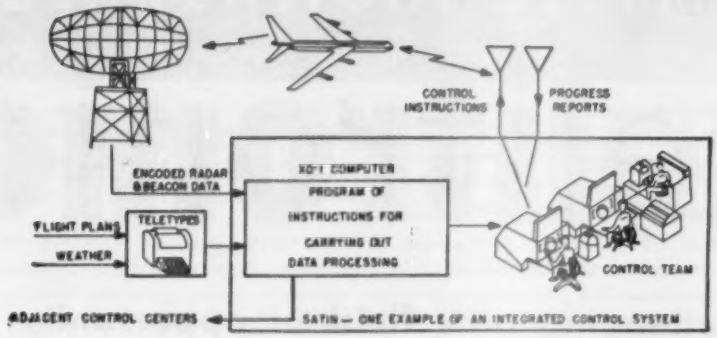

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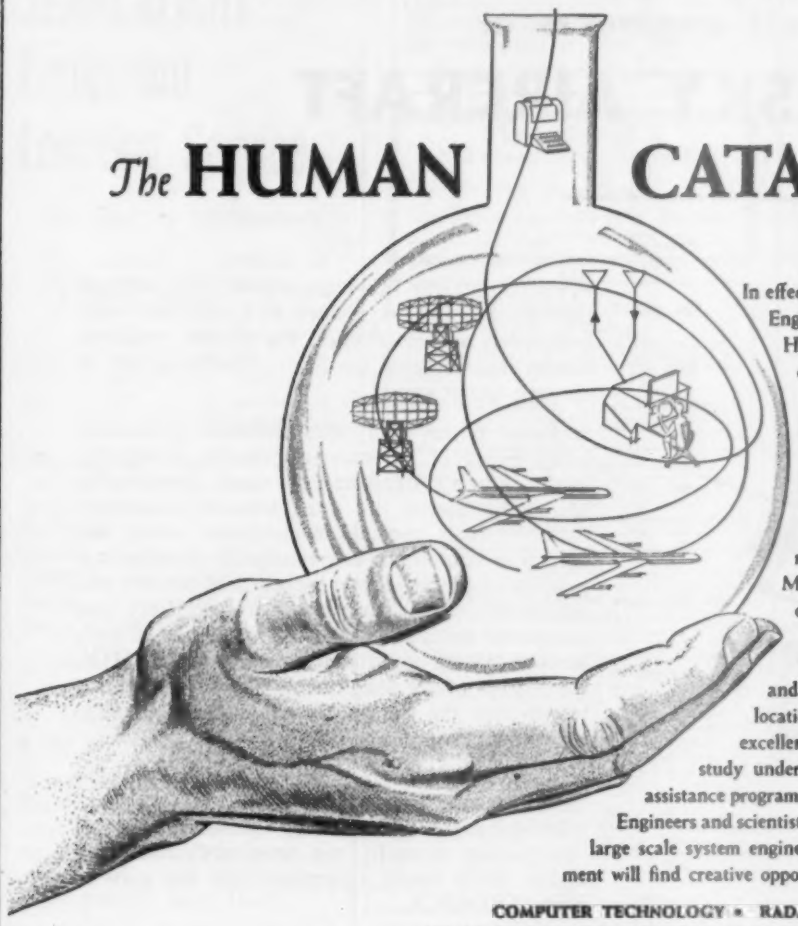

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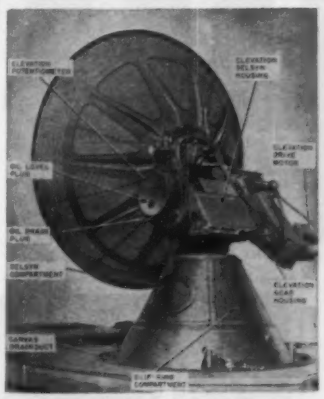

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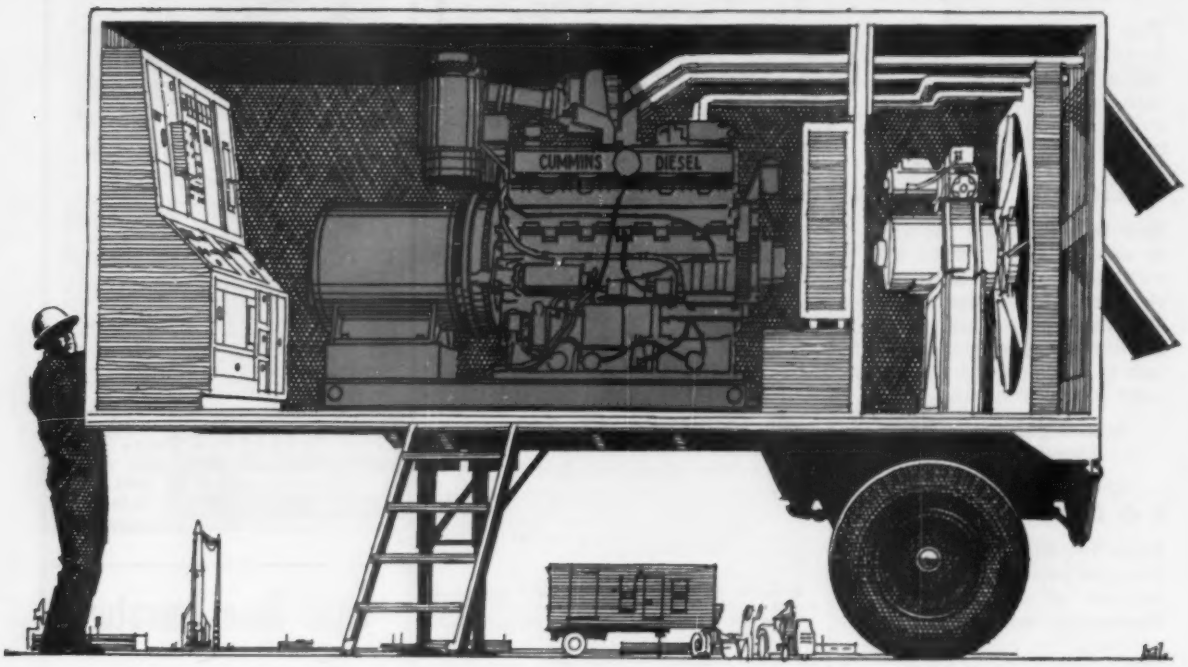

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LETTERS

U-2 Photos

I've been awaiting with great interest for an explanation of why a page of pictures of the U-2 aircraft appeared in AVIATION WEEK a full week before the announcement of the U-2 incident (especially in view of your statement that the aircraft was practically of World War II vintage).

Was it just an interesting coincidence?

WILLIAM L. JACKMAN
Ft. Huachuca, Ariz.

(AVIATION WEEK *published a page of pictures showing various configurations of the U-2 operating out of Atsugi airfield in Japan on p. 158 of its May 2 issue. The U-2 piloted by Francis G. Powers was lost over the Soviet Union on May 1.* AVIATION WEEK *never described the U-2 as "practically World War II vintage," but said it represented aeronautical state of the art in mid-1950s.—Ed.*)

Saving Our Country

I can no longer resist joining the mob writing you about how to save our country. In the unlikely event that this excessively long letter is published, I request that you withhold my name and address, as I would like these views to be taken as those of a citizen rather than those of an extra-curricular salesman for my company.

Although there is no simple solution for our defense problems, I feel there are two factors which must be responsible for much of the difficulty: organization and lack of analysis.

Organization. Long before the birth of our country, it had become accepted that soldiers fought on land and couldn't tell a main sheet from a bed sheet, while sailors fought at sea where mud was only the bottom of their arena. Thus, two services, separately administered and with separate missions and technologies. In this twentieth century, the new environment of the air has led to a painful extrapolation of the old order, and we now have three separate services. The scene is already set for a further extrapolation to four services, as soon as the who-should-be-in-outer-space argument finally becomes intolerable. Yet, we really have only two military missions: deterrence of total war, and the capability of containing and winning limited war.

With each of the three services wanting to do both of the available jobs, it is hardly surprising that inefficiencies result. The trouble is that each service (naturally) tries to promote those weapons arbitrarily defined as being within its own bailiwick, regardless of the relative worth of the other services' weapons in accomplishing precisely the same mission. For example, sober evaluation of the relative merits and optimum mix of Polaris and Minuteman becomes lost in an avalanche of biased and conflicting propaganda, all designed to wrestle more money away from the other fellow's program. In the past we have seen similar squabbles, such as Thor vs. Jupiter, P6M vs. B-52, Nike vs. Bomarc, and so on. There are also slightly different arguments, such as whether TAC is buying the kind of aircraft that can support the Army in a small war. Thus, archaic organization has sapped much of the energy that should be devoted to the U.S.A.-USSR contest for survival and applied it to the Army-Navy-Air Force contest for money and prestige.

The solution here, I feel, would be first to get at the heart of parochialism by coalescing the existing services into one unit. This should mean the end of different uniforms, different service academies, different words for the same ranks and grades, and all the other arbitrary divisions which serve to cloud the fact that we are all on the same side.

The second step would be to align the combat forces according to function. Aside from a superior coordinating body, this single service would be divided into one group whose sole mission would be the deterrence of total war, and a second group whose major mission would be the maintenance of limited war capability, although certain of its weapons, though optimized for limited war, could be applied in case of total war. The former group would comprise such existing elements as SAC, ADC, and the Polaris program, together with such logistic and supply forces as might be required. The latter would comprise the remaining elements, such as the entire Army, the rest of the Navy and Marine Corps, TAC, MATS, MSTS, etc. Each of these groups would be able to select the most appropriate weapons for its mission, free of today's petty considerations of whether they float, roll, fly, or stand on a column of flame. The fact that this could not be accomplished overnight is a poor reason to deny such a reorganization.

Lack of Analysis. Though this country is blessed with a number of excellent programs, some others have gone through a great deal of money before their inherent fallacies were noticed. The Air Force is easiest to pick on in this respect, possibly because, having had so much money in the past, it may not have been quite so careful in the selection of its weapons. For example, the B-70: here is an aircraft which is supposed to fly so fast and so high that the enemy can't touch it. Yet, it would be surprising to hear any reputable manufacturer of surface-to-air missiles admit that he couldn't build a product that would kill this monster and have it ready by the appropriate time period. Still, cries for this aerodynamic toy persist in spite of the indicated superiority of other concepts for manned aircraft delivery systems.

Though the Navy is perhaps a bit more lean and hard, having been on a stricter money diet, it is not totally blameless in the logic of all its systems either. For example, the "Triton": this largest of all submarines is advertised as a radar picket for air defense of a task force. To perform this mission, it must operate on the surface which has two notable characteristics: the worst possible place for an air defense radar (where line-of-sight prevents detection of low altitude aircraft), and the worst possible place for a submarine (where its great advantage of invisibility is lost). Yet both these catastrophic concepts have been combined into a single towering monument to absurdity.

Perhaps the reason for this kind of thing is that operations analysis groups are usually tucked away in a corner, lower in rank than weights, structures, powerplant, aerodynamics, and other assorted groups, and used only to "prove" what the boss wants proved. The solution is to put them into chronological first place in the procurement chain, where the merit of a new system must be demonstrated before everyone begins passing out money for hardware.

So much for my thoughts—organization by function rather than by history, and thought before action. This seems so obvious and logical that I am forced to admit that it is totally unlikely.

CONCERNED CITIZEN
Huntington, N. Y.

Aviation Week welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to the Editor, Aviation Week, 330 W. 42nd St., New York 36, N. Y. Try to keep letters under 500 words and give a genuine identification. We will not print anonymous letters, but names of writers will be withheld on request.

Defense Financing

Congratulations to Jim Radcliffe (AW May 16, p. 158) for his fine answer to the spenders (Mr. Lanphier and company). I, too, am one of those people who want to know where the money is to come from when the hue and cry is raised for more spending. The question of financing extravagant defense programs seems to be noticeably lacking from AW's editorial pages. Is not the threat of eventual national bankruptcy just as serious as present Soviet missile strength?

MARTIN P. BLACK
Alexandria, Va.

(*No. 1—Ed.*)

Idlewild Terminals

This letter is being written in reference to the picture that appeared in the May 2 issue (p. 127), "Airline Passenger Terminals Under Construction at Idlewild."

In the picture it states that building (2) is the American Airlines terminal building and (4) is the Eastern Air Lines terminal building. If you check you will find out that these buildings are in reverse. Number two is really the Eastern terminal and number four is the American terminal.

I have been an avid reader of AVIATION WEEK for two years and I would like to keep things straight.

MICHAEL L. TIMCHEK
Student
Tulane University
New Orleans, La.

(Reader Timchek's observation is correct. —Ed.)

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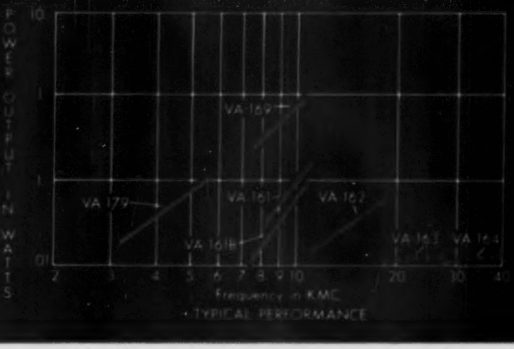
A LINE OF RUGGED, PM FOCUSED BACKWARD WAVE OSCILLATORS



Varian now offers a line of permanent magnet focused backward wave oscillators in frequency ranges to cover a wide variety of circuit application requirements. All models feature small size, low voltage operation, long life expectancy and rugged construction. These tubes are available either from stock or on short delivery schedules. The metal and ceramic construction offers the most reliable tube at the lowest cost and assures dependability in severe environments. Typical applications for Varian BWO's are: signal generators, electronic countermeasures and systems requiring frequency agility.

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